



GCSE

Chemistry

8462/1H Paper 1 Higher Tier

Report on the Examination

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General comments

Over 120 000 students sat this component, so a very wide and varied range of responses was seen.

Many students gave responses that showed excellent and comprehensive understanding of Chemistry at GCSE level, although others had difficulty even with basic chemical concepts.

Poor use of correct technical terminology hampered some students in several questions which required a clear distinction between types of particle; ‘atoms,’ ‘ions’ and ‘molecules’ were sometimes used indiscriminately or not at all.

Levels of 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.

There were nine questions on this paper. Questions 1, 2 and 3 were common to the Foundation Tier. The demand levels of the questions are designed to increase from standard demand to high demand through the paper. From question 4 onwards, the demand of each question also increases through the question. As expected, students generally had more difficulty gaining credit in the high demand questions towards the end of the paper. However, the vast majority of students attempted all the questions.

A student’s final grade, however, is based on their attainment across the qualification as a whole, not just on questions that may have been targeted at the level at which they are working.

Comments on individual questions

Question 1 (standard demand)

- 01.1** Two thirds of students gained both marks, with nearly all scoring one mark. A few incorrect salts were named, such as copper chloride and copper sulfide, and sometimes hydrogen was given as the third product instead of water.
- 01.2** Nearly three quarters of students were awarded the mark for this question. The question asked for an observation to show that the reaction was complete. Those who stated that the solid would no longer react were simply rewording the question and did not gain credit. A statement of copper carbonate no longer disappearing or still being visible did gain credit, and this was the approach taken by the vast majority of students. The idea of a product forming rather than remaining did not gain credit. Only a few recognised that bubbling would stop.
- 01.3** More than 3/4 of students were awarded the mark. Most answered correctly in terms of removing the excess copper carbonate. A few gave generalised answers about filtration removing solids that were not specific to this salt preparation and therefore did not gain credit.

- 01.4** Students were expected to give one of the two methods in the specification, ie a water bath or an electric heater. Many, however, simply stated that a Bunsen burner would be used. This was an insufficient response unless a beaker of water was also present. Less than half of students scored the mark.
- 01.5** The great majority of students were able to substitute the values and rearrange the expression to give the correct answer. Some students used their calculator incorrectly, using both the % button and also dividing by 100, giving an answer that was a factor of 100 too low. They seemed unfamiliar with the idea that the symbol '%' means divided by 100. A minority of students tried to incorporate the 50 cm³ into their calculation.
- 01.6** This question proved surprisingly difficult, although it did discriminate well. Only a sixth of students scored both marks, with half of students not gaining credit at all.

Students were expected to recognise that copper would not react with an acid, and that the reaction with sodium would be too vigorous to be safe. There were some excellent answers for the lack of reactivity of copper in terms of its position below hydrogen in the reactivity series. However, there were many poorly phrased answers that implied there might be some reaction with copper, and also many that described copper as a transition metal but did not link that to reactivity in any way. There were also some excellent answers in terms of the consequences of the high reactivity of sodium, although some did not go far enough; they simply stated that sodium is too reactive without saying why that is a problem. A minority of students thought that the metal would be displacing sulfur if it reacted.

Question 2 (standard demand)

- 02.1** This was very well answered by the majority of students, with nearly two thirds scoring both marks. Most stated that both atoms have one outer shell electron and that potassium has one more shell than sodium. Sometimes the wrong number of shells was given for the two elements; usually 2 shells for sodium and 3 for potassium. Some stated that potassium has more outer shells than sodium. This is not correct as the phrase 'outer shell' is always taken to mean the single outermost shell. Some students gave consequences of the electronic structure rather than referring to the electronic structure itself; this was not given credit. Simply stating that the number of electrons is different did not answer the question; the number of electrons is not the electronic configuration.
- 02.2** More than two thirds of students gave two correct observations, with bubbling and a flame being the most popular. 'Gas produced' did not gain credit as it is not an observation but a deduction from the observation of bubbling. 'Fizzing' is taken to mean effervescence, so fizzing and bubbling are the same thing rather than two different observations. Credit was not given for any observation requiring extra equipment such as a thermometer or an indicator.
- 02.3** Well over half of students gave a correct colour and a correct reason, either in terms of the solution being alkaline or containing hydroxide ions. Nearly three quarters of students gained one mark. Some students had evidently seen, and remembered, the experiment done with phenolphthalein in the water, and therefore stated the indicator colour to be pink even though they knew the solution to be alkaline. Some answers were not clearly expressed; 'potassium is an alkali' did not gain credit as it is the potassium hydroxide solution that is alkaline. There were

also, however, some excellent answers in terms of the hydroxide ion produced causing the solution to be alkaline.

- 02.4** More than four fifths of students plotted all of their points accurately. Many also drew a line of best fit although this was not required. A few drew their points as small dots instead of crosses, making it very difficult for the examiners to see them on a scanned image. Points do need to be visible, albeit sharp.
- 02.5** Students could nearly always estimate the density of krypton to within the tolerance allowed. Many used a line of best fit to do so although this was not necessary. In some cases inappropriate methods were used, such as finding the mean of all the other values; this did not gain credit even if it gave a value within the range allowed.
- 02.6** Three quarters of students identified the correct pair of solutions, with the spread of incorrect responses being approximately equal.
- 02.7** Over two thirds of students identified the correct pair of trends. Most of the incorrect responses thought that boiling point decreases down the group.

Question 3 (standard demand)

- 03.1** Nearly all students could name the plum pudding model, but most described model B as the nuclear model rather than the Bohr model (the nuclear model would not have the electrons in fixed orbits). This was, however, accepted, as the Bohr model is an adaptation of the nuclear model. Some students described model B as the atomic model, which simply rewords ‘model of the atom.’ Some described model B as the modern model, which contradicts the information that both were early models of the atom.
- 03.2** The features of each model were very well known and students scored highly on this question, with over half scoring full marks and more than nine tenths reaching level 2. The structure of many answers, however, sometimes made it difficult to see whether a comparison had been made. Many students described one model and then the other, rather than writing a true comparison of the features of each, with one feature compared at a time. Some of the best answers were written in the form of a table, with comparisons such as ‘no nucleus’... ‘has a nucleus.’ To score full marks it was necessary to note a similarity as well as differences, with the most common similarity being ‘both models have electrons.’ One fairly common misconception is that the plum pudding model had an overall positive charge, rather than the positive charge being countered by the charges on the electrons, giving a neutral atom overall.
- 03.3** Many students knew that isotopes had different numbers of neutrons but did not say that isotopes were atoms with the same number of protons or of the same element. Thus, only a third of students scored both marks, although five sixths scored one. Some referred to ‘elements’ with the same number of protons, which did not gain the first marking point. Some students appear to believe that an isotope is a single atom where the number of neutrons is different to the number of protons, for example ‘an atom with more neutrons than protons.’ Some students’ answers made it clear that they think there is only one ‘true’ atom of an element, with isotopes being improper deviants.

Question 4 (standard and standard/high demand)

- 04.1** Just over two fifths of students correctly drew two straight lines, with the ascending line having an even scatter either side of the points, and the horizontal line avoiding the anomaly. Some lines were doubled or feathered so did not gain credit. Some drew two different curves, each encompassing all the points, and made them cross somewhere. This gained no credit. Students should be aware of the sort of graph produced by this required practical.
- 04.2** This question discriminated well, with a quarter of students scoring 3 or 4 marks and the great majority scoring at least one mark. The question asked students to explain the results, but many simply described them. It was not sufficient just to describe the temperature increasing with the addition of more zinc; reference to the reaction being exothermic was also needed. The fact that the maximum temperature change occurred when 0.80 g of zinc was added was the mark scored most often, but many students were also able to explain this turning point in terms of no further reaction being possible because the zinc was now in excess. There were some excellent answers in terms of the zinc being the limiting reactant up to 0.8 g, after which the copper sulfate became the limiting reactant.
- 04.3** Some excellent answers were seen; however, fewer than a quarter of students scored both marks and only three fifths scored at all. The question asked why a polystyrene cup gives a more accurate result, so answers needed to be phrased in comparative terms. Polystyrene is a better insulator than glass, but it is not true that polystyrene is ‘an insulator’ and glass is ‘a conductor,’ since both materials insulate and conduct thermal energy to different extents. Similarly, many answers implied that no energy is lost from a polystyrene cup, which is not true.
- 04.4** Nearly two fifths of students were able to give the correct formulae of the products but the state symbols were sometimes incorrect. A common incorrect formula was Zn^{2-} . There was sometimes no clear distinction between upper and lower case letters; the n and u need to be discernibly smaller than the Z and the C. Many students tried to give formulae of compounds rather than just the ion or atom.
- 04.5** The vast majority of students were able to calculate the mean. Fewer than half were also able to express the mean and the uncertainty correctly. Some students only averaged the highest and lowest values, which calculates the median rather than the mean. Although the mean and the median are the same in this particular set of values, this method did not gain credit. Some students calculated the uncertainty by halving the range. This calculates the range about the median, rather than the definition in the specification which is the range about the mean. This method was given credit on this occasion, although it is not strictly correct.
- 04.6** Students found this question difficult, with fewer than a quarter scoring the mark. Despite the information that there were no measurement errors, many students gave a type of measurement error as their answer. Reading the method carefully would have pointed out that the starting temperature was neither measured nor controlled, so may have fluctuated, and that stirring is inherently inconsistent. Some students had evidently done the practical using a lid and referred to it being replaced at different times; this was given credit.

Question 5 (standard, standard/high and high demand)

- 05.1** This question required the use of precise scientific language in responses, which was a major difficulty for many students. Only one in eight students scored all four marks, with more than a third not scoring at all. Although the question asked students to describe what happens to atoms of calcium and chlorine, many failed to include the word ‘atoms’ when referring to calcium and chlorine. ‘Calcium’ and ‘chlorine’ refer to the elements in bulk, not to individual atoms. Similarly, the ions formed were often not referred to as ions either by name (chloride, not ‘chlorine’ ions) or by formula. It is the resulting ions which have complete outer shells, not atoms. Some students did not read the question properly and described the electrolysis of calcium chloride rather than its formation. Some students described the transfer of electrons from calcium atoms to chlorine atoms correctly, but then referred to the atoms ‘sharing’ electrons.
- 05.2** Only two fifths of students could give a correct answer in terms of the lack of mobility of the ions. Many students referred to the inability of electrons to move rather than ions. Some said that substances have to be molten or in aqueous solution to be electrolysed but did not say why that was the case.
- 05.3** Fewer than half of the students knew that hydrogen was the product. Calcium was the most popular incorrect response, with chlorine and hydrogen ions also being named as the product.
- 05.4** Two thirds of students identified the correct half equation, with the most popular distractor being the reverse half equation, with chlorine as a reactant rather than the product.
- 05.5** Over half of students recognised that the Cu^{2+} ions were moving towards the negative electrode, and that the CrO_4^{2-} ions were moving towards the positive electrode. However, less than a third deduced that Cu^{2+} ions are blue and CrO_4^{2-} ions are yellow, with many referring to the ‘formation’ of those colours rather than their separation. Some tried to refer to electrode processes, even though the diagram shows that the ions in question have not yet reached the electrodes. Many failed to refer to ions at all, referring instead to ‘copper’ and ‘chromium oxide;’ these gained no credit. Some students seem to believe that copper is blue (rather than copper ions).

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

- 06.1** Over three fifths of students scored all three marks. Most students could list the metals in order of decreasing reactivity, although some ignored the sign and ordered the metals in order of absolute magnitude of voltage. A few tried to remember the reactivity series, even though nickel and silver are not listed in the specification. The best answers justified the order not only in terms of the most reactive metal producing the most positive voltage, but also that the negative voltages were produced by elements less reactive than nickel.
- 06.2** This extended response plan of a non-required practical discriminated very well. About a third of responses reached Level 3, with more than two thirds reaching level 2.

There were some excellent descriptions of a plan which would work, including details of how the different concentrations to be tested would be made. Some students thought the pure water was to be used as a control rather than for diluting the sodium chloride solution. The top mark in Level 3 was only available if there was detail about how the voltage could be linked quantitatively to the concentration of sodium chloride. This was often poorly expressed using terms such as

‘amount’ rather than ‘volume,’ and did not always mention both the sodium chloride solution provided and the water. The control variable ‘use the same two metals each time’ was essential to access a Level 3 mark, since the method must lead to a valid outcome. This was often implied in responses where a student named different metals, or stated they must be different, and then said, ‘repeat using different concentrations of sodium chloride.’ Many students, however, specified that all of the different metals should be used, which was completely unnecessary and possibly rendered the outcome invalid.

A common error was to use two electrodes of the same metal, or to refer simply to ‘the electrodes’ without specifying what type of electrodes to use. This restricted the answer to Level 2.

It was not uncommon to see reference to a power supply, which restricted the answer to Level 1; there is some confusion between an electrolytic cell and an electrochemical cell.

- 06.3** Only 1 in 25 students scored both marks by repeating the statement in the specification that hydrogen is oxidised electrochemically to produce water, and only a quarter of students scored one mark. There were a few excellent answers showing the half equations at both electrodes; as long as these showed hydrogen losing electrons, and water being a product, they gained full credit. Those who referred to hydrogen losing electrons in the fuel cell gained credit; however, students often thought that hydrogen ions were reacting, rather than hydrogen molecules. Other types of oxidation, such as combustion, were not accepted. Some students appear to believe that the water is produced as steam, which then drives a turbine generating electricity.

Question 7 (standard, standard/high and high demand)

- 07.1** Only a quarter of students gained both marks, and a third did not score. Many students described how solids in general conduct thermal energy, rather than answering the question which is specifically about conduction in a metal. Many students realised that the process has something to do with delocalised electrons. However, many described how electricity is conducted, rather than thermal energy. The idea of the delocalised electrons transferring thermal energy through the metal was not at all well known. As the question asked how thermal energy is conducted, repetition of the word ‘conduct’ did not help to explain the meaning of that word.
- 07.2** This question discriminated well, with over a half of students scoring 2 or 3 marks. There were many well-expressed, complete answers. Common errors often involved an attempt to describe some sort of stronger bonding (sometimes covalent or ionic) in the alloy. Some lost credit because of poor use of language; it is not ‘metals’ which are different sizes, but their atoms (or positive ions). A common error was to refer to different shapes of atoms. ‘Particles’ is also insufficient as it could refer to other types of particle than atoms. ‘Intermolecular forces’ were often referred to, although they are not present in either a pure metal or an alloy.
- 07.3** Just over a half of students identified the correct equation, spotting that the mole ratio of Fe:Cl₂ was 2:3. The most popular distractor was $\text{Fe} + \text{Cl}_2 \rightarrow \text{FeCl}_2$, where the student had ignored the information provided about the reacting number of moles.
- 07.4** Only two fifths of students identified the correct response by working out the total charge of the various combinations and choosing the one with a net zero charge. $3\text{Fe}^{2+}:\text{4O}^{2-}$ was a very popular distractor, with $3\text{Fe}^{3+}:\text{4O}^{2-}$ not far behind.

- 07.5** Over three quarters of students obtained full marks on this question. For those who did not, it was sometimes difficult to award any credit because the M_r had not been evaluated. Common errors were $56/M_r \times 100$ or $64/M_r \times 100$. Some students attempted to bring in the 0.12 and 0.18 from question **07.3**, which was about a different compound.
- 07.6** Those students who understand moles had little difficulty with this question; almost a half scored at least 4 marks. The most common error was a failure to convert the mass of Fe_2O_3 to grams. Some students attempted to calculate a volume of Fe_2O_3 , not appreciating that it is a solid as shown by the state symbols in the equation. Some students unnecessarily calculated the mass of carbon dioxide before converting this to a volume. The mole ratio was sometimes applied incorrectly to the mass of Fe_2O_3 . Despite being given the M_r of Fe_2O_3 as 160, many students used 320 instead. Whilst this sometimes led mathematically to the ‘correct’ answer, it is incorrect chemistry and full credit was therefore not awarded.

Question 8 (standard, standard/high and high demand)

- 08.1** This question discriminated very well. Whilst more than a half of students scored at least one mark, only one in seven scored all three. Few students recognised that it is the structure of propane as small molecules that is important rather than it being a hydrocarbon with single bonds. Most did not mention the structure at all. Although many students used the term intermolecular forces, it was clear that many did not know what this phrase means as they referred to ‘intermolecular forces between atoms’ or ‘between bonds.’ These students did not gain credit for the forces being weak or needing little energy to overcome. Some, who correctly referred to intermolecular forces being weak, then described little energy being needed to break bonds rather than to break the intermolecular forces. This is a question where clear and precise use of language is absolutely critical.
- 08.2** Over three quarters of students identified the correct reaction profile. The most popular distractors were **A** and **D**.
- 08.3** Over a quarter of students gained full marks on this high demand question, with half of students gaining at least 4 marks. Sometimes working was very difficult to follow; there was a page full of additions and subtractions with no words to explain what these represented. Just the words ‘broken’ and ‘made’ would have clarified the working enormously. The students who scored 4 marks had usually failed to recognise that the reaction is exothermic and therefore 2219 (the magnitude of the energy change) is given by (bonds made – bonds broken) since the energy for bonds made must be the larger value in an exothermic reaction. It should be noted that ΔH and its sign convention are not in the GCSE specification. Other common errors included: not including the C–C bonds: counting 3 C–C bonds instead of 2; complete omission of the value of the energy change.

Question 9 (standard, standard/high and high demand)

- 09.1** Over a half of students knew that a weak acid is one which is partially ionised, although many forgot to state that this was in aqueous solution. Some students incorrectly stated that an acid is ionising (ionises other species) rather than ionised (is itself ionised). Some incorrectly stated that it was H^+ ions which are ionised or dissociated, rather than the acid molecules. The H^+ ions are the result of the ionisation or dissociation.

- 09.2** Two thirds of students realised that the pH would increase. Some did not give the direction of the change, saying the pH would become ‘closer to 7’ but not saying from which direction. Far fewer were able to articulate the reason in terms of the decrease in concentration of hydrogen ions. There were, however, some excellent answers in terms of the decrease of the number of hydrogen ions per unit volume.
- 09.3** Many students gave three or four correct steps in the procedure. However, many omitted to say that the alkali should be measured with a (volumetric) pipette, which is an essential step, so did not gain full marks. Most students remembered to add an indicator, although some suggested using universal indicator, which is not suitable for a titration. Most also suggested using a white tile, and many correctly said that the titration should be carried out in a conical flask. Carrying out the titration in a beaker did not gain credit because of the risk of spillage while swirling. Those who suggested taking the initial burette reading, or filling to a particular reading, often expressed themselves poorly; a burette does not give readings of ‘amount.’
- 09.4** Over two thirds of students scored one mark, but fewer than a half scored both. The most common approach was to calculate the volume in dm^3 and then convert to cm^3 . Students who took this approach very often scored at least one mark, either by converting an incorrect volume to cm^3 or getting the first step right but forgetting to convert the units. A common error was to multiply the moles and concentration together.

Students who took the alternative approach, converting the concentration to mol/cm^3 first, were less successful; they often multiplied by 1000 in the first step instead of dividing and then did not know how to use the number of moles.

- 09.5** This high demand question discriminated well; fewer than a third of students scored all three marks but nearly three quarters scored at least one mark. The best answers picked up on the information that calcium atoms are larger, and applied knowledge about reactivity in Group 1 metals to this unfamiliar context. Imprecise language lost some students credit: ‘electrons are further away’ mentions neither the outer electrons nor the nucleus; ‘force between the outer electrons and the nucleus’ does not specify an attractive force; ‘more outer shells’ is not correct because ‘outer’ is always taken to mean the one shell furthest from the nucleus. It was not uncommon to see the force between the nucleus and the outer electrons described incorrectly as intermolecular. Some students referred to the larger size of the atom as if this referred to a lump of calcium and tried to answer in terms of larger surface area for the acid to attack giving a higher rate of reaction.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the [Results Statistics](#) page of the AQA Website.