GCSE
Chemistry
8462/1H

Report on the examination

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General comments

Over 115 000 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 this Higher Tier GCSE level, although others had difficulty even with basic chemical concepts.

Imprecise use of language caused problems for many students. One example is the use of ‘amount’ instead of volume, mass etc. ‘Intermolecular forces’ is a term which is used indiscriminately by many students, often inappropriately. Some students appear to believe that forces between any type of particles are intermolecular; this is only the case if the particles in question are actually molecules. Ionic, covalent and metallic bonds are not intermolecular forces, and intermolecular forces do not exist between ions, atoms or bonds.

Students should read the question carefully to see if comparative answers are needed or not. For example, if asked why one substance is used instead of another, comparative answers (more, less etc) are required as in question **03.4**. However, if a question is only in terms of a single substance, such as in question **06.1**, the use of comparative terms such as ‘more’ energy to break bonds is not appropriate and not creditworthy.

The accurate use of subscripts and superscripts is fundamental to chemistry, and is expected in word processed, as well as handwritten, answers. If the word processing package used does not allow for subscripts and superscripts, the student needs to indicate their use in some way, for example using ^ to indicate a superscript.

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 Only a quarter of students scored the mark, despite the clear statement in the specification. Many referred to the right of the table, but fewer referred to the top. Those who referred to specific groups were often correct but some omitted Group 0. Some referred to a 'staircase' but did not specify what it means; it should be noted that the periodic table provided does not show a staircase.

01.2 More than three quarters of students correctly chose the low melting point as the atypical property. The last distractor, 'forms positive ions' was the least popular, but the other distractors were about equal.

01.3 Nearly all students drew the electronic structure correctly. A few tried to use either 12 or 23 electrons.

01.4 Only two fifths of students were able to make sensible comments about the properties of the elements and either the groups that they would have been in or the groups that they were moved to. However, many comments were not clear, either not mentioning <u>similar</u> properties to the rest of the group or referring to vague regions of the periodic table rather than groups. Some stated that the elements were placed in order of atomic number, but atomic number was not known at Mendeleev's time, so these answers were disregarded. Some referred to leaving spaces for elements that had not been discovered, which does not answer this particular question.

01.5 Students scored well on this question, with more than two thirds scoring both marks and nearly all scoring at least one. Most referred to argon having a full outer shell of electrons, although some stated that there were no electrons in the outer shell, which is meaningless as the shell is not present without electrons. Fewer scored the second mark, for explaining that argon does not gain, lose or share electrons. Very few mentioned that the electron arrangement is stable; some said that argon is stable, which is just a rewording of the question.

01.6 The vast majority of students knew that isotopes have the same number of protons but a different number of neutrons. However, just over a half did not state that isotopes are <u>atoms</u> with the same number of protons, or <u>atoms</u> of the same element, so were restricted to one mark. Some implied that an isotope is a single atom where the number of neutrons is different to the number of protons, as in carbon-13.

01.7 The vast majority of students estimated the A_r correctly as ~115. The most popular distractor was ~114. Some students did not realise that an actual calculation was not required: only an estimation from the huge proportion of the isotope with mass number 115.

Question 2 (standard demand)

02.1 Fewer than half of students could count the ions and realise that the ratio was 1:1 so the formula is CaS. Some tried to do it from the formulae of the ions but often wrote $CaSO_4$. Ca_9S_9 was a common incorrect answer, as was 9CaS. A formula was required, not an equation; equations did not gain credit.

02.2 More than three fifths of students gave fully correct answers, and nearly all scored at least 3 marks. The main omission was not saying what ions were formed. Students sometimes contradicted themselves by describing the atoms sharing electrons as well as those electrons being transferred. Any mention of sharing electrons negated the first three marking points. The correct formula of the sulfide ion was sometimes contradicted by an incorrect name such as 'sulfur ion' or 'sulfate ion'.

02.3 This was well answered by the majority of students, with two thirds reaching level 2. The question discriminated well. Many referred to the giant structure, the layers, the covalent bonds and the delocalised electrons. Fewer referred to the hexagonal rings of carbon atoms, with some incorrectly referring to the layers themselves as hexagonal. Many tried to refer to each carbon atom having three bonds, but some could not express themselves clearly, for example by leaving out the word atom or by implying that the whole structure contained only 3 bonds or 3 atoms. Fewer referred to the strength of the covalent bonds, with some incorrectly saying that covalent bonds are weak. Many also referred to the lack of covalent bonds between layers or the presence of weak intermolecular forces between the layers, but some referred to intermolecular forces without specifying their location. Very few referred to covalent bonds being shared pairs of electrons or to the fact that there is one delocalised electron per carbon atom. Many students introduced properties of graphite, which were not asked for and did not gain credit.

02.4 Very few gave the expected answer, which is the syllabus statement that small molecules do not have an overall electric charge. Some did try to refer to this but were not clear enough; 'they do not have an overall charge' does not necessarily refer to the small molecules since the subject of the sentence was 'substances. More than half did score the mark, but this was usually due to a reference to the lack of delocalised electrons. Some stated that there was no space for delocalised electrons, which is not the same thing and did not gain credit. Some stated that there are no mobile ions, which is ambiguous as it could mean that there are ions, but they are not mobile; this would not be correct.

02.5 Just over a half of students gave the correct reason, with 'poly(ethene) has more covalent bonds to break than methane' being the most popular distractor. Some ticked 2 boxes – usually the first and last; this automatically scores zero when the instruction is to tick **one** box.

Question 3 (standard demand)

03.1 This was answered less successfully, with the majority of students choosing tin as the substance reduced. Tin is the product of the reduction, not the substance which is reduced. Those who did choose the correct substance, SnO_2, were usually able to give a correct reason; one in seven students were awarded both marks. Some tried to answer in terms of electrons, despite the instruction to answer in terms of oxygen. These answers did not gain credit for the second marking point.

03.2 Nearly three quarters of students managed to state succinctly that carbon is more reactive than tin or that tin is less reactive than carbon. However, some answers were vague and used the word ‘it’ which is problematic as there are three substances named in the question. ‘Carbon is more reactive’ is insufficient as we do not know what the reactivity is being compared to.

03.3 More than two thirds of students achieved full marks. Some did not calculate a total M_r but used the M_r of CdO instead; these answers were not creditworthy. Others added up all the M_r of reactants and products instead of just the reactants; these gained partial credit.

03.4 The question asked for two differences in properties, so comparative language was necessary (potassium is softer rather than potassium is soft). Three fifths of students scored both marks, choosing from differences in physical properties and properties exhibited by transition metals only. The most common type of error was to describe differences in atomic structure rather than differences in the properties of the metals in bulk.

03.5 The vast majority of students interpreted the equation correctly and showed that the total M_r on both sides was 238.

03.6 More than two thirds of students gave an acceptable response. Most of those who were awarded the mark answered in terms of economic reasons such as lowering the cost of the operation. Fewer answered in terms of sustainable development; of those who did, most referred to a high atom economy producing less waste. Some students confuse a high atom economy with a high yield; references to yield were ignored.

Question 4 (standard, standard/high and high demand)

04.1 More than two thirds of students were able to estimate the boiling point from the bar chart. A generous range was allowed, from -70 °C to -20 °C. A surprising number of students gave 0 °C or a positive value.

04.2 Three quarters of students were able to use the bar chart to deduce that -250 °C is below fluorine’s melting point, so fluorine must be a solid at that temperature. Many stated fluorine to be a gas at that temperature, preferring to rely on what they ‘knew’ about fluorine than to analyse the data.

04.3 Nearly all students gave the correct answer. Some produced an answer of 3, perhaps by trying to work out the detailed electronic configuration instead of simply looking at the group number.

04.4 Fewer than three fifths gave a correct answer. Students were expected to give the formula HAt by analogy with HCl. AtH was also accepted. However, there were many instances of H_2At, HAt_2, H_2At_2 or 2HAt. Some students tried to write an equation, which is never an appropriate response when asked for a formula and did not gain credit.

04.5 This question discriminated well, with nearly all students gaining at least one mark but only one in seven scoring all four. Precise use of language was required. Most students were able to state that reactivity decreases going down Group 7. Many were also able to state that gaining an electron became more difficult going down the group, although some referred incorrectly to likelihood rather than difficulty. Far fewer students were awarded the other two marks. Many said 'they' or 'the elements' become larger or 'they' or 'the elements' have more shells rather than specifically referring to the atom. Others stated that electrons, rather than outer shell electrons, become further from the nucleus. Some stated incorrectly that atoms have more outer shells. All atoms have one outer shell. Many students referred to the attraction between the nucleus and the outer shell, rather than between the nucleus and the electrons in the outer shell. Some incorrectly described this attraction as intermolecular or gravitational. Those who tried to refer to shielding usually found difficulty in expressing the idea correctly. Some brought in trends in melting and boiling points, which were not relevant.

04.6 This question also discriminated well, with nearly two thirds of students gaining at least one mark and one third gaining all three. Most students who could write the correct formulae could also balance the equation. However, there were many incorrect formulae, with errors such as Br instead of Br_2, KI_2 instead of KI, and even interhalogen compounds as products such as BrI. Compensation marks were available for those who could write the correct formulae for the two halogens and / or the correct formulae for the two potassium halides. There was no credit for balancing incorrect formulae.

Question 5 (standard/high and high demand)

05.1 Over half of students scored both marks by giving the description in the specification. For the first marking point, the idea of both the shape and the charge were needed. Common errors were to refer to a positive 'cloud' or a ball of positive 'energy'. Other errors were to refer to protons, which had not been discovered, or to imply that there was an overall positive charge on the atom as a whole; atoms were known to be neutral in terms of charge. For the second marking point the electrons needed to be referred to as such, not just negative charge. Common errors were to imply that electrons were on the surface rather than embedded, or that they were moving.

05.2 This was well answered, with four fifths of students scoring at least one mark. Many referred to the mass being concentrated at the centre and also the positive charge but failed to refer to the centre as the nucleus. Many referred to most of the atom being empty space, but some simply said that there is empty space in the atom which is not quite the same. Fewer referred to electrons orbiting the nucleus, and many of those who did referred incorrectly to shells.

05.3 Whilst many students knew that Bohr's contribution to the model of the atom was electron shells, many did not mention that the electrons were orbiting the nucleus in these shells. Even fewer referred to specific distances from the nucleus. Many confused Bohr with Chadwick and stated that Bohr discovered neutrons. Only one third of students gave a fully correct answer.

05.4 More than four fifths of students gave the correct response, with 10 000 times larger being the most popular distractor.

05.5 Two thirds of students gave fully correct answers. Most students could calculate the volume correctly, although some incorrectly gave the units as nm instead of nm^3. They had more difficulty with the surface area, with some forgetting to multiply the area of one face by 6 and others miscounting the number of faces. The marks for calculating the ratio could be obtained from incorrect values for the surface area and / or volume. The simplest ratio was required, so this needed to be either a whole number ratio or with one of the values reduced to 1. Dividing one value by the other was by far the simplest way of finding the ratio. A few students unnecessarily decided to change the units from nm to m, mm or even μm. As this ratio is not dimensionless, this approach gave different values depending on the units chosen. Full marks could be obtained if the conversions were correct, but many were not. If students are not instructed to give an answer in particular units, they should stick with the ones provided.

05.6 Students found this question more difficult than expected, with fewer than half scoring one mark and about one in ten scoring both. Many students gave the general answer; that nanoparticles have a greater surface area to volume ratio. However, fewer were able to express clearly the idea that a thinner coating could be used, with many using ambiguous phrases such as 'less nanoparticles needed' rather than less of the coating or another description of less material in bulk. Fewer concentrated on the specific use in glasses. Although many said that visibility would not be reduced as much if nanoparticles were used, many thoughts this would be because the particles themselves could be seen if fine particles were used, which is not the case. Some students did not give answers in comparative terms, for example referring to a high (rather than higher) surface area to volume ratio.

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

06.1 This was a high demand question which required the use of correct terminology. The question discriminated well, with three fifths of students gaining one mark but very few scoring all four. Many students referred correctly to strong electrostatic forces of attraction and to the large amount of energy needed to break these. Fewer referred correctly to the particles that those forces acted between, i.e. the oppositely charged ions; some referred incorrectly to the forces being between bonds. Some referred to 'oxygen ions' rather than oxide ions. There were very few who stated that the electrostatic forces act in all directions in the giant structure, despite the statement in the specification; this was the mark that most students did not score. Some students ruined their answer by the use of the word 'intermolecular', which is not appropriate as there are no molecules. Most students did recognise that a lot of energy was needed to break bonds but had contradicted this marking point earlier in their response by referring to the bonds as intermolecular forces. Some referred to 'more' energy being needed to break the bonds; this did not gain credit because the question did not require a comparison to anything else, and 'more' does not necessarily imply 'a lot'.

06.2 Only a half of students knew that cryolite was the correct substance. The most common incorrect answer was water.

06.3 Only one in five students scored the mark. Many students missed the point and referred to allowing ions to flow. The idea that the mixture has a lower melting point than pure aluminium oxide so that less energy is required was not well known. It is not correct to say that the melting point of aluminium oxide is lowered, as aluminium oxide has a fixed melting point. Some appear to think incorrectly that cryolite is a catalyst.

06.4 Students had difficulty with this high demand question, but it did discriminate well between the higher achieving students. One in five students scored both marks. Many could not write the formula of the oxide ion, and of those who could, some had the oxygen on the left and the oxide ion on the right. Those who could write the correct formulae could often balance the equation correctly, with the correct number of electrons on the right. An electron must be written with its charge in an ionic equation, as e^-, so that the charge balances as well as the atoms.

06.5 This question discriminated well, with half of students scoring at least one mark and more than a third scoring all three. Those who knew that the positive electrode is made of carbon often went on to score all three marks, although some merely referred to oxidation of the electrode rather than a specific reaction with the oxygen produced. There appeared to be much guesswork, with unspecified corrosion of an electrode made of an unspecified material being fairly common. Some thought that the deterioration of the electrode was due to its gaining electrons, and some thought that the electrode was made of iron and would rust.

Question 7 (standard/high and high demand)

07.1 Whilst the majority of students reached level 1, only one in eight gave sufficient linked reasons to reach level 2. This was a high demand extended response question with the command word 'evaluate'. Merely making comparisons from the information in the table was insufficient to gain credit. Consequences of those comparisons were necessary to count as linked reasons. An overall judgement or several individual judgements were necessary to reach Level 2, but many answers contained no judgement at all.

Many students were able to link the states at room temperature to a consequence such as hydrazine being easier to store or transport. Many were also able to link the need for a catalyst to potential extra costs. However, they had difficulty with consequences of the other information in the table. Most students do not realise that when comparing data in an AO3 question, sometimes there is no real advantage of one option over the other and that is a valid point to make. Many tried to justify why being explosive was more dangerous than being toxic or vice versa, instead of simply deducing that both were dangerous in different ways. A large proportion of students seem to think that nitrogen is harmful in some way, rather than deducing that neither fuel cell produces harmful products. Few students deduced that the larger voltage from hydrazine means that fewer fuel cells would need to be used in a battery; instead, they merely stated that more power would be produced from a single hydrazine fuel cell. Some students tried to refer to atom economy, which is not relevant in this context as there is no 'desired product'.

07.2 More than half of students scored both marks, and nearly two thirds scored at least one. A common error was to draw two pairs of electrons in the overlap between the two N atoms, despite the ball and stick model above showing all single bonds. Some miscounted the electrons on the two N atoms because they used the same symbol for the electrons from both. Some avoided this by using a combination of dots, crosses and open circles or other symbols. The question was not attempted by some students, suggesting that they did not read the question because there were no answer lines and therefore did not realise, they had to do something.

07.3 The question asked for an advantage of the ball and stick model; those answers which referred only to a disadvantage of the dot and cross diagram did not gain credit. Fewer than half gave one of the expected answers, in terms of the ball and stick model being 3-D rather than 2-D or showing the shape of the molecule. Answers that did not gain credit included the idea that the ball and stick model shows: the structure (both do); the arrangement of atoms (both do); the relative sizes of the atoms (both do), or referred to showing the atoms, rather than the molecule, in 3-D. Other vague responses such as 'better visual representation' did not gain credit.

07.4 There were many fully correct answers, with working set out clearly; nearly a half scored full marks. Those who did not complete the calculation correctly could score partial credit for working out that the energy to break bonds is 2062 + **X** kJ/mol and / or that the energy involved in forming bonds is 2801 kJ/mol. Credit was also given for correct use of incorrect values of these totals. Common errors were: leaving out the **X** for the bonds broken; ignoring the overall energy change of 581 completely; adding the 581 to the bonds formed instead of subtracting it or adding it to the bonds broken.

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

08.1 Three quarters of students could give the correct formula for the hydroxide ion. The most common error was H^+. A surprising number did not attempt to answer.

08.2 This was surprisingly answered less successfully, with fewer than two thirds gaining a single mark and very few scoring all four. Many suggested using phenolphthalein or methyl orange instead of Universal Indicator, but few were able to express the reason in terms of a sharp or sudden colour change rather than the gradual change seen with Universal Indicator. The next most common improvement was to add the sodium hydroxide solution dropwise near the end point, but again the reason was not clear, with 'results' or 'amount' often stated instead of 'volume', and 'precise' instead of 'accurate'. These words are not synonymous.

There were many spurious 'improvements' such as having the acid in the burette and the alkali in the flask; it does not matter which way round the solutions are used. Some think that a measuring cylinder is more accurate than a pipette – they are confusing a pipette used for measuring volume with a dropping pipette.

08.3 The vast majority gave the correct reading. The most common error was 25.3 cm^3.

08.4 This question discriminated well. Nearly a half gave fully correct answers, while two thirds were able to score at least one mark, often for applying the correct mole ratio. A common error was to use the mole ratio the wrong way round, giving an answer of 0.24 mol/dm^3, or to ignore the mole ratio completely, giving an answer of 0.48 mol/dm^3. Sometimes the volumes were not converted to dm^3, leading to incorrect statements such as 'moles acid = 5.4'. Whilst these responses often led to the answer of 0.96 mol/dm^3, they did not gain full credit. Sometimes the volume conversion was attempted but incorrect, eg multiplying cm^3 by 1000. Students who tried to bring masses into the calculation were rarely able to make any progress.

08.5 The vast majority chose the correct statement, but a minority thought that the hydrochloric acid was more concentrated as well as stronger.

08.6 Students struggled with this high demand question, with only one in ten scoring one mark. The question demanded precise use of technical terms and use of the data in the table. Few mentioned the concentration of hydrogen ions, so could not gain credit; they referred to 'number' of hydrogen ions or 'more' hydrogen ions (in an unspecified volume) or concentration of 'acid'. Even fewer calculated the concentration of hydrogen ions in each acid from the data in the table, to back up their argument. Many students seem to think that pH depends only on the strength of an acid. pH depends on the hydrogen ion concentration, which in turn depends on a combination of both the strength and the concentration of acid molecules. Many also seem to think that acids are ionising, rather than ionised.

Question 9 (standard/high and high demand)

09.1 This question discriminated well. Nearly all were able to reach level 1, with two thirds reaching level 2 and one third reaching level 3; one in six students were awarded full marks. This was an AO3 question which required students to apply techniques they had learned in a required practical to a new situation. There were many excellent answers, with students realising that the first step should be to make a solution of iodine in ethanol and then carry out a normal salt preparation adding excess zinc, filtering, and crystallising the solution. The most common error was to ignore the flammability of ethanol and heat with a direct flame instead of over a water bath or electric heater. Some students ignored the instruction to use zinc and iodine, using zinc oxide, zinc hydroxide or even zinc carbonate. Many students believed that iodine is a liquid or should be used in aqueous solution; this was not penalised as the students' experience of iodine is probably only as a solution. This did lead to problems for some students, however, as they believed that both ethanol and water were present. Those who missed out a key step, such as adding excess zinc or filtering to remove the excess zinc, were limited to level 2. Those who started with the product, zinc iodide, were limited to level 1.

09.2 Nearly a half of students gained full marks in this calculation and over three quarters could make some progress. This was a multi-step calculation, which is classed as an extended response question. As such, the working has to make sense chemically. Those students who managed to put the data together in such a way as to obtain an answer of 78.9%, but whose working made no sense chemically, were often limited to the mark for the correct number of significant figures.

There were many excellent fully correct answers, and many students were able to make some progress by calculating the number of moles of iodine and / or zinc iodide. While most adopted the expected approach, calculating the expected mass of zinc iodide and finding the actual mass as a percentage of that value, two other valid approaches also gained credit. One of these was to find the moles of zinc iodide produced as a percentage of the expected moles. The other, far less commonly seen, was to find the mass of iodine actually reacted and take that as a percentage of the mass provided. Of those who adopted the approach of calculating the expected mass of zinc iodide, many surprisingly calculated the mass of zinc and added that to the mass of iodine, rather than simply multiplying the number of moles by the M_r of ZnI_2, which was provided. Students had little difficulty in rounding correctly to 3 significant figures.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.