GCSE
CHEMISTRY

8462/1H Paper 1
Report on the Examination

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General comments

Well over 100,000 students sat this component, so a very wide and varied range of responses was seen.

Many students gave responses which showed excellent and comprehensive understanding of Chemistry at this Higher Tier GCSE level, while others had difficulty even with core chemical concepts.

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 ten 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 two fifths of students scored both marks, although three quarters scored at least one mark. The plum pudding model is described in the specification. However, some students referred to a ball of positive energy rather than positive charge, and some did not name the electrons, or implied that they were outside the positive ball rather than embedded in it.

01.2 Nearly three fifths of students could give the correct order of discovery.

01.3 More than three quarters of students scored both marks by locating tennessine in Group 7 and therefore deducing that it has 7 outer shell electrons. Some ignored the instruction to use the periodic table and tried unsuccessfully to work out the electron configuration.

01.4 Only one fifth of students were familiar with the idea of peer review or could apply it to this situation. A common incorrect reason was the scarcity of the element; this was the same for the original group of scientists so does not explain the delay.

01.5 Two thirds of students gave fully correct answers, and the question discriminated well. The great majority scored at least one mark, for giving an attempt at the calculation to one decimal place. Some divided by the sum of the mass numbers instead of the sum of the percentages (ie 100). There were very few rounding errors. Some students did not realise that their answer must lie somewhere between 6 and 7, the two mass numbers of the isotopes.

Question 2 (standard demand)

02.1 This was answered very well, though a few students referred to amount rather than mass, or got the two variables the wrong way round. Nearly three quarters of students scored both marks.

02.2 Most students could plot the points accurately, though some found the scales difficult, particularly on the x-axis. The majority drew good straight lines of best fit, with a scatter of points either side of the line. However, some struggled with drawing a line of best fit when there is a scatter of points. Some drew 'point to point' lines, while others had a majority of points above (or below) the line.

Students should always plot their points in pencil, as well as using a pencil for the line of best fit. It is very difficult to amend a point plotted in ink, and in the case of ambiguity the examiners will not give the benefit of the doubt.

02.3 The great majority of students extrapolated the line correctly and read the correct value from the y-axis.

02.4 Nearly four fifths of students answered correctly in terms of the decrease of temperature. It was not necessary to refer to energy transfer as that is not shown in the results; however, those who did so usually referred correctly to energy being taken in. Those who contradicted their answer by giving an incorrect reference to energy being given out did not score the point.

02.5 This was not well answered, with fewer than half of students obtaining a mark. Many students were able to explain that the results ranged from 0.3 °C below the mean to 0.3 °C above the mean. However, few students said that 0.3 °C is the uncertainty in the results. Some students think that the uncertainty is half of the overall range (ie the range about the median) rather than the range about the mean as stated in the specification. In this particular question the median and the mean were numerically equal, but that is not always the case.

02.6 Fewer than a half of students gave the correct answer, random error, although this was the most popular answer. Systematic error was the second most popular response; however this would not have given a scatter of points.

Question 3 (standard demand)

03.1 This question discriminated very well, with nearly two fifths of students giving a Level 3 answer, another third reaching Level 2, and nearly all of the others reaching Level 1.

Many students gave excellent descriptions of the salt preparation, although many did not state which acid would be used in order to obtain zinc chloride. Some students only described the crystallisation process, leaving out essential steps such as starting with the acid, adding excess of the zinc carbonate, and filtering out the excess. A few would not have made crystals because they evaporated to dryness by heating. Many students appear to believe that the acid is being evaporated off the solution, rather than water. There were infrequent references to using a water bath of an electric heater for the evaporation; use of a Bunsen burner directly is likely to lead to heating to dryness. A few students seem to think that every practical activity is an investigation, trying inappropriately to name independent, dependent and control variables.

03.2 Many students could name at least one correct substance, with two fifths scoring both marks and another third scoring one mark.

Question 4 (standard and standard/high demand)

04.1 The great majority of students gave the correct answer, with most of the rest split evenly between the first option (adding the three bond energies together) and the third (subtracting only one H—Cl bond).

04.2 This question discriminated well and there were some excellent answers that described the energy released in making new bonds being greater than the energy required to break old bonds. However, some implied that energy is required in both steps, and others only referred to the bond making process, omitting a consideration of the bond breaking process. There were misconceptions with some students referring to gases being lost and taking energy with them, and others responding that an exothermic reaction is one that loses matter, rather than energy.

04.3 This question discriminated well; half of the students were awarded all three marks, while nearly all scored one mark. Most students drew an exothermic profile, but fewer labelled the products. Those who drew an endothermic profile could still access the second and third marking points. A few did not complete the profile so were only able to access the mark for the activation energy. There were some arrows for the activation energy and overall energy change that were untidily drawn which made it impossible to judge whether they started and finished at the correct place. This is one example where using a ruler really does help the student. A few labelled the top of the curve as the activation energy, rather than the gap between the energy of the reactants and the top of the curve.

04.4 Nearly three quarters of students scored both marks. Many fully correct diagrams were seen. The majority of students chose to use the format with a ring around each atom, but answer without rings were equally acceptable. A few students drew an extra electron on either hydrogen or carbon, and some drew ions instead of a molecule.

04.5 This question proved to be difficult, with few students giving fully correct answers to gain all 4 marks and with a third of students gaining no credit.

To answer the question, students needed to compare the size of the molecules, hence the strength of the intermolecular forces, hence the energy required to break those forces and hence the boiling/melting points. However, many students did not mention molecules at all, seeming to believe that the polymer is a giant structure. There was much confusion between bonds and intermolecular forces. Students sometimes think that by including both intermolecular forces and covalent bonds they will cover all eventualities, but this often results in contradictions which lose marks. Students often thought intermolecular forces had to be broken in methane but bonds had to be broken in poly(ethene). Many did not refer to the energy requirement or to the melting or boiling point.

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

05.1 More than half of the students were able to state that a weak acid is one which is only partially ionised or dissociated in aqueous solution. Common incorrect responses were that the acid is partially ionising (it does not ionise other species) or that hydrogen ions are ionised (it is the acid molecule which ionises to form H^+ ions). Attempted responses in terms of pH were not accepted.

05.2 The great majority of students gave the correct response. The most common distractor was the mass of acid dissolved is halved and the volume of the solution is doubled, which would decrease the concentration. The other two options would not change the concentration.

05.3 Fewer than a third of students could recall the name of an appropriate indicator and the correct colour change from this required practical. Any single acid-base indicator was allowed, with its associated colour change. Phenolphthalein was the most popular choice of indicator; with phonetic spellings accepted. The colour change was often the wrong way round, as acid is being added to the alkali, and some students described the final colour incorrectly as ‘clear’ rather than colourless.

05.4 About three fifths of students knew that the OH^- ion is responsible. When asked for a formula, an equation is not an appropriate response.

05.5 This question discriminated very well. Some scaffolding was given to help the students and bring the demand of the question down. This resulted in two fifths of students scoring full marks on the question and nearly three quarters scoring at least one mark.

Some intermediate marks were not awarded because students didn’t convert the volume into dm^3 when calculating the number of moles of sodium carbonate. A second mark was then often not awarded in calculating the concentration of nitric acid because students divided by a volume in cm^3 instead of dm^3. Those students who tried to bring relative formula masses into the calculation (when no data had been given to enable them to do so) rarely scored more than two marks; one for applying the mole ratio and one for rounding an answer to 3 significant figures if all the data supplied had been used.

A few students did not use the method suggested, but used a ratio method instead. On this occasion full credit was given to these answers. However, students should be aware that purely mathematical methods, which do not demonstrate an understanding of the chemical principles, are not always appropriate.

05.6 Over a third of students scored the mark in this high demand question. As the pH has decreased by a factor of 2, the concentration of hydrogen ions increases by a factor of 10^2. However, many students did not realise this and attempted to calculate a concentration by applying a linear, instead of logarithmic, scale factor. Some students divided by 100 instead of multiplying.

05.7 Only two fifths of the students worked out that the element must be argon. Sulfur was a popular incorrect response (one electron subtracted instead of added), but other halogens were also popular.

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

06.1 Nearly a half of students gave Level 3 answers, nearly all of the others giving Level 1 responses. However, fewer than one in six students reached the top of Level 3.

In order to reach Level 3, at least one judgement was necessary. Many students misinterpreted the question and thought that just one metal should be used for all three uses, instead of selecting the best metal for each individual use. These students usually chose copper on the basis of its high electrical conductivity and low cost; these students were able to score 3 marks. The best answers gave reasoned judgements for all three uses, based on a consideration of cost and/or density for overhead cables, conductivity and cost for wiring in homes, and tiny amounts of material required for printed circuit boards. Many students did not realise the significance of the density in the selection of a metal for overhead power cables, and its lack of importance for the other uses. Some incorrectly related density to strength, malleability or other properties. Others stated that because 'the government' pays for overhead cabling, cost is not an issue.

Many students wasted time and space quoting actual figures from the table, which is unnecessary. 'Copper is nearly as conductive as silver but far cheaper' conveys the essential points without any actual figures. Examiners expect the students to analyse the figures and add value to the data given in a table.

06.2 Nearly a quarter of students gave fully correct answers, with most able to score at least one mark. The majority of students knew that electrical conductivity is due to delocalised electrons, and most referred to electrons as charge carriers. However, many merely referred to the movement of electrons as being 'throughout' the structure, meaning everywhere within it, rather than 'through' the structure, meaning a unidirectional movement (when a pd is applied) rather than random movement. Some students referred to electrons transferring charge from one to another; this is not correct.

06.3 Nearly a third of students scored at least one mark on this high demand question, which required the linking of two different areas of the specification. Students needed to link what they knew about alloys (distorted layers due to different sized atoms) to electrical conductivity, to suggest that the distorted layers would impede the flow of electrons. Some students seem to think that the atoms in an alloy have different shapes.

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

07.1 Nearly all students could balance the ionic equation correctly.

07.2 About a fifth of students answered this high demand question correctly. Some students compared the reactivity of sodium with hydrogen instead of with aluminium. Imprecise language was sometimes a problem; it is elemental sodium which is more reactive, not sodium ions. Aluminium is released at the electrode, not discharged (it is the ion which is discharged, ie loses its charge). There is no displacement occurring.

07.3 The question discriminated well, but very few fully correct answers were seen, with just over a third of students scoring at least one mark. Students were asked to explain <u>how</u> oxygen is produced from water, not <u>why</u> oxygen is produced. Few students described the initial step outlined in the specification; that water molecules break down to form H^+ ions and OH^- ions. Many seem to think that oxide or 'oxygen' ions are responsible, rather than hydroxide ions. The attraction of the hydroxide ions to the positive electrode was reasonably well known, but few students then correctly described the oxidation or discharge of the hydroxide ions to form oxygen. As in the previous question, the term 'discharged' is widely misunderstood – the word means 'loses its charge', so to say that oxygen is discharged is not correct.

07.4 Nearly two thirds of students scored at least one mark, but just over half of these also scored the second mark. The easiest change to the apparatus is to change the test tubes to measuring cylinders or inverted burettes. Many students suggested gas syringes; this was allowed, although it would be difficult to set up the apparatus in such a way that this would work. However, a ‘gas cylinder’ is not a measuring device. One popular misconception is that gas would escape from the apparatus so a lid should be used.

Most students realised that the reason was so that the gas volume could be measured rather than estimated, or that test tubes have no scale; any equivalent way of expressing this idea was allowed. Some students used imprecise language such as ‘so the gas could be measured’ without referring to volume or a scale.

07.5 The great majority of students gave the correct response, with 20 cm^3 being the most common incorrect choice.

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

08.1 This question was well answered, with nearly all students referencing the stability of the outer electron shell. ‘Full outer shell’ was accepted even though it is not strictly true for a Period 3 element. About a half of students also referred to the lack of ability to share or transfer electrons, but some simply repeated that argon does not form compounds or does not form bonds. This was insufficient as the question required students to answer in terms of electrons.

08.2 About three fifths of students were able to give a correct formula by analogy with ammonia. PH_2 was a common incorrect response.

08.3 More than two fifths of students scored both marks, with nearly two thirds scoring at least one. Those who failed to score usually did not answer in terms of the position in the periodic table, as required. Students could reference the position on the right, and/or towards the bottom, or in Group 6 (the most common answer) to deduce whether or not a reaction would occur. However, many just stated that tellurium has six electrons in its outer shell, without mentioning the position.

08.4 About two thirds of students scored one mark, but far fewer were able to give a second valid observation. The most common observation was effervescence / bubbling / fizzing, but sometimes students used two of these words as if they were separate observations. Students sometimes gave deductions (gas produced, heat produced) instead of the actual observation (bubbling, temperature increase). Other common errors were to give observations which might be seen in any chemical change (eg formation of a precipitate, or a colour change) rather than this specific one.

08.5 Over a third of students scored at least two marks on this high demand question, with most of these students scoring all three marks. Nearly three quarters scored one mark, usually for the formula H_2. Those students who managed to work out the correct formula for barium chloride often scored all three marks. Some students were unable to work out that barium chloride and hydrogen would be the products. It was not uncommon to see the wrong symbol for barium, despite its being given at the top of the page.

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

09.1 Students found this question difficult, with only a tenth of students scoring both marks and not many more scoring one. Most students gave incorrect responses for the substance reduced: usually iron, but sometimes carbon. Those who gave the correct substance were usually able to give the correct reason in terms of loss of oxygen. It seems that students are so well versed in the definitions of redox in terms of electrons (as in question 09.3) that they have forgotten the simpler definitions in terms of gain or loss of oxygen.

09.2 Fewer than a third of students gave the correct answer, with all three distractors being very popular. This suggests a large degree of guessing rather than using the equation to work out the mole ratio of C:Fe as 3/2 and then multiply by 12 grams.

09.3 Over three-quarters of students could correctly apply their knowledge of redox in terms of electrons. By far the most common incorrect response was **A** gains electrons and $\mathbf{B}^{+}$ loses electrons.

09.4 Fewer than one in seven students answered this high demand question correctly, with the great majority giving metal **A** as the answer. It was necessary to realise that the greatest tendency to form positive ions means the most reactive metal. It was then necessary to work out from the three reactions in the table that **A** is more reactive than **B**, **C** is more reactive than **A**, and **C** is less reactive than **D**, making **D** the most reactive.

09.5 This question discriminated well. Over half of students scored at least one mark, with just over one in ten scoring all three.

Many students tried to answer in terms of the reactivity series. This was not possible, as insufficient detail was provided to identify any of the four metals. The formula of the nitrate ion was provided but was not referenced by the majority of students. The key to answering the question was in the formulae of the nitrates; aluminium forms an ion of charge 3+, so each ion requires three nitrate ions to balance the charge. Even when students got the basic idea, they often did not express themselves clearly enough, using phrases such as ‘aluminium has a 3+ charge’ rather than referring to an aluminium <u>ion</u>.

09.6 Those who understood the concept of atom economy were able to complete this difficult calculation successfully; over a fifth of students scored all four marks and two fifths scored at least one.

There were two main approaches. One was to substitute values into the atom economy expression, followed by successive rearrangements of the expression to give the value of A_r of **X**. A neater solution, used by students who had a good understanding of atom economy, was to realise that the remaining 22.7% was the total M_r of the waste atoms, ie 54, and then scale either to 100% and subtract the 54, or scale straight to 77.3%. Many students misunderstood the M_r of XO_3, thinking it meant the A_r of **X** times 48. Some also misunderstood $3H_2$ or $3H_2O$, giving various values for what should have been a total of 54 for the M_r of the waste atoms. Nevertheless, correct manipulation after these errors allowed access to 3 marks.

Question 10 (standard/high and high demand)

10.1 About a third of students scored one mark, but far fewer scored a second mark. Many students did not give comparative answers. Many referred to nanoparticles having a larger surface area, but failed to realise that this depends on the amount used. A higher surface area to volume ratio, or a higher surface area for the same mass of material was creditworthy and was the most common correct answer. This leads on to other creditworthy answers, such as a thinner coating being needed, and hence, more light getting through the window, but these answers were rarely seen. References to cost were ignored.

10.2 This question discriminated well. The great majority of students scored at least one mark, with nearly a half scoring five or six marks. The most common error was not converting 100 kilograms to grams in order to calculate the moles, or converting incorrectly. Another common error was to calculate a spurious volume of TiO_2. Some converted the number of moles of chlorine to a mass first, before converting to a volume; whilst unnecessary, this did give the correct answer and gained full credit. Students who gained one or two marks usually calculated the relative formula mass of TiO_2 and/or converted 100 kilograms to grams. A few seemed to be concerned by the large value of the answer and introduced a division by 1000 into what would have been a correct answer.

Students sometimes tried more than one method and did not cross out the one they did not want to be marked. This led to confusion and contradictions, sometimes meaning that marks could not be awarded. Students should always cross out discarded methods; examiners will not make the choice for the student.

Mark Ranges and Award of Grades

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