GCSE
CHEMISTRY

8462/1H

Report on the Examination

8462

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General

This was the first year of the reformed specification. Students appear to have been well prepared, and coped well with the increased length of the paper, the larger number of questions requiring an extended response, and the greater number of calculations.

Questions 1– 3 were common to the Foundation Tier.

Some answers to multiple choice questions caused problems because students were not ticking one box. Some students put a line through the options they are discarding from consideration; they should not do this, as it can look very much like a tick.

Lack of precision of language caused issues for some students. They are advised to avoid the word ‘amount’, which is never specific enough. They should refer to volume, mass, amount in moles, as appropriate.

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.

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.

Question 1 (standard demand)

01.1 This question was well answered, with 70% of students able to give a different type of substance. Many suggested a base, but as metal oxides are themselves bases, this was not another type of substance and was ignored. Named examples of correct types of substance were accepted.

01.2 38% of students could write the correct formula for calcium nitrate. Many didn't know what to do with the nitrate ion even if they worked out the ratio as 1:2.

01.3 This question discriminated well, with marks across the range being spread fairly equally. Whilst there were many excellent answers, a lot of students concentrated on the crystallisation phase, without saying how the magnesium sulfate solution would be produced.

Some started by adding magnesium sulfate to an acid. A few students mixed unspecified quantities of magnesium oxide and sulfuric acid in an evaporating basin and then evaporated to dryness, sometimes stating that the acid was being evaporated off. Even when an oxide is correctly added in excess and the excess filtered off, evaporation to dryness will not yield crystals.

Question 2 (standard demand)

02.1 Because the question asked for the formula rather than the empirical formula, an answer of Fe_9S_{18} was accepted. Even so, 51% of students could not count the atoms and produce a ratio of 1:2. A formula was required, not an equation which some students provided.

02.2 This was very well answered, with 88% of students achieving all three marks.

02.3 57% of students achieved both marks. However, some repeated information in the stem of the question, and some contradicted it by saying sodium is not a metal. Some gave differences in the structure of the atoms instead of differences in properties of the substances.

02.4 This was well answered, with 32% of students achieving one mark, and 57% achieving both.

A common error was to say that carbon is reacting with oxygen (it is not; it is reacting with nickel oxide to remove the oxygen). Those who tried to answer in terms of electron transfer often struggled to gain all the marks.

02.5 This question was well answered, with 60% of students achieving all three marks. However, interpretation of calculator displays did cause a bit of trouble for some students. Some students lost the final mark because they gave an answer of $67.\dot{8}$. This answer is neither correct (it is not 67.8888888…) nor to three significant figures (it is to an infinite number of significant figures). Some even recognised this latter point and rounded, incorrectly, to 67.9.

Question 3 (standard demand)

03.1 This was well answered with 67% of students recognising that there had to be two different metals, and that water alone would not be suitable as the electrolyte. A significant number of students incorrectly ticked more than one box.

03.2 62% of students answered this question on a new area of the specification correctly. Many, however, mixed up the answers to questions **03.2** and **03.3**. Many thought that charge, energy, or a product run out.

03.3 52% of students could answer in terms of the lack of reversibility of the chemical reaction in the cell.

03.4 This was well answered, with 70% of students able to give the formula for oxygen and then to balance the equation.

03.5 96% of students achieved three or more marks. However, many students limited themselves to level 2 as they just used the information from the table, without bringing in any of their own knowledge. Others failed to give a judgement on which method is better; a judgement is an essential part of a question where the command word is ‘evaluate’.

Some students wasted space and time requoting data from the table. A comment such as ‘you can go much further with a hydrogen fuel cell before having to stop to refuel’ is a better answer than ‘you can go 415 miles between refuelling with a hydrogen cell car but only 240 miles between recharges of a lithium-ion battery car’.

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

04.1 87% of students could identify the plum pudding model from the diagrams. E was the most popular distractor, where the charges were reversed.

04.2 68% of students could identify the model resulting from the alpha particle scattering experiment. The Bohr model was the most popular distractor.

04.3 72% of students could identify the Bohr model correctly. The most popular distractor being the model from the alpha particle scattering experiment.

04.4 69% of students could define mass number correctly. Some lost the mark by writing 'protons and neutrons' with no further information. Others mistakenly gave a description of relative atomic mass, or referred to the total mass of the protons and neutrons instead of the total number.

04.5 This question was well answered, with 75% of students able to estimate (or calculate) the relative atomic mass.

04.6 19% of students achieved all three marks. Two marks could be obtained just for defining isotopes. The other mark was for linking this to Chadwick's discovery of the neutron. No knowledge of how he made this discovery was required.

Many students were able to recall that Chadwick discovered the neutron, and that isotopes have different number of neutrons. Many students didn't mention that isotopes have the same number of protons, or are atoms of the same element. Clarity of expression was important here; the statement that isotopes are different forms of the same element gained no credit as it could refer to allotropes. Similarly, 'mass of an element' does not mean 'mass of an atom'.

Some students appear to think that isotopes are not 'normal' atoms of an element, and some think that isotopes are always unstable. There was some confusion of Chadwick with Rutherford, and even with Mendeleev.

Question 5 (standard and standard / high demand)

05.1 This question was done very well, with 94 % of students achieving both marks. The few that did not score both marks usually omitted to label their bars.

05.2 This question was very well answered, with 77% of students achieving both marks. The most common error was suggesting that the reactions were not endothermic because the copper experiment did not increase in temperature. This seems to suggest an unclear understanding of exothermic and endothermic reactions. Other common errors were in the use of language, such as the ‘heat increases’ (for temperature), or ‘temperature is given out’.

05.3 It was expected that students would simply repeat the same experiment with the unknown metal, giving details of variables to be controlled in order to produce valid results. However, many students decided to go down a different track, and full marks could be achieved from methods involving:

- adding all of the five metals to an acid
- adding the unknown metal to salt solutions of the other four
- measuring either the temperature change or some measure of the rate of reaction
- heating the unknown metal with oxides of the other four
- using the unknown metal as one electrode in a series of electrochemical cells and measuring the voltage produced.

8% of students achieved full marks, and 53% achieved two or more.

The most common missed mark was for the control variable. Though some realised that a control variable was necessary, use of the ubiquitous ‘amount’ was all too frequently seen and did not gain credit.

The method involving displacement reactions was very common but not very successful, with vague references to adding the metal to unspecified solutions, or to metal oxides without heating, or to other metals. Some students wanted to add the metals to water, without recognising that these four metals would not react with water, so they would only be able to place the unknown if it were the most reactive. Other students placed the metal in relation to carbon or hydrogen rather than to the other four metals as required by the question.

There was some confusion between making results valid (by using control variables to give a fair test) as opposed to accurate (by cutting down energy exchange with the surroundings), which did not gain credit.

05.4 Many excellent answers were seen, although there were some very sloppy diagrams. 54% of students achieved two or three marks.

- A significant number had drawn an endothermic curve, but then went on to label it correctly so were able to access two of the three available marks.
- A small number drew the correct curve, but then did not put on the labels.
- Some labelled reactant and product lines incorrectly as start and end temperature.
- Some attempted labels by, for example, drawing a line / arrow from the right to point at the top of the curve and labelling it incorrectly as activation energy.

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

06.1 Students found it difficult to score both marks on this question, although 77% of students scored one or more marks. Lower-attaining students simply stated that the electrolyte was a solid, without further explanation. Others incorrectly referred to the movement of delocalised electrons, rather than ions. Some refereed to zinc instead of zinc chloride.

06.2 Students struggled to put sufficient detail into their answers, although no more was required than what is directly stated in the specification. 9% of students achieved all three marks.

A lot of weakly expressed ideas were seen. Instead of stating that each atom forms three covalent bonds, many students stated that graphite has three covalent bonds, or that three out of four carbon atoms are bonded, both of which are untrue.

Very few said that each carbon atom has one delocalised electron: a statement directly from the specification. Those who did score the marks for the structure often didn't say that delocalised electrons move or carry charge **through** the structure. They often implied the delocalised electrons just moved around at random. Many students misunderstood the process of electrical conductivity completely, thinking that it is something to do with layers sliding over each other.

Some students referred to other properties such as softness, instead of confining their answer to the question posed.

06.3 58% of students did not achieve a mark for this question. The investigation was stated to be about the relationship between volume and time, but the diagram showed no means of measuring volume. The expected answer was to use inverted measuring cylinders so that volume (not 'amount') could be measured.

Although it would pose practical difficulties, the idea of using gas syringes was also accepted (on the grounds that it could be made to work if they were attached to funnels placed over the electrodes). Many suggested changing the electrodes as graphite is not inert, suggesting a lack of understanding of the required practical. Some students suggested that the apparatus is upside down.

06.4 Although 75% of students achieved one mark, usually for the trend in the hydrogen graph, just 7% achieved three marks.

In order to score the mark for proportionality of the hydrogen graph, both variables had to be stated, not just 'it is proportional'. Alternatively, a steady rate of collection would gain the mark. It had not been anticipated that students would calculate the rate of collection, but those who did were awarded credit. Some referred to proportionality correctly, but did not state which gas they were referring to.

The chlorine line posed more difficulty. Many described the chlorine line after 8 minutes as proportional. It is not as it shows a linear relationship, where the volume of chlorine increases at a steady rate.

Students are very unsure of how to describe trends in curved graphs; the idea of the chlorine being collected at an increasing rate (which could be expressed as faster and faster) being very rarely seen.

As in other questions, the language used by students created a barrier to attaining marks. 'It remains constant' could mean the gas volume no longer changes, rather than the rate of collection.

06.5 2% of students were able to answer this question. Many students either had not read or understood the statement that the number of moles of each gas produced is the same.

There were attempts to justify the difference in terms of reactivity, formula mass, size of molecules, pressure difference or the concentration of H^+ and Cl^- in solution. Some students referred to the length of time taken for the chlorine to react, rather than to be formed. Others suggested the molar volume was different for different gases, ignoring what they know from the part of the specification on gas volumes.

The formation of chlorine and hydrogen is part of the electrolysis required practical, so students should not be completely unfamiliar with the bubbles of chlorine taking longer to form. They should also be familiar with 'chlorine water' from their work on Group 7.

06.6 Students found this calculation on a new area of the specification quite difficult, with 26% of students providing a fully correct answer.

It was necessary to read off the correct volume from the graph and change the units from cm^3 to dm^3, or to change those of the gas molar volume to cm^3/mol, but many students didn't do this. Many students also struggled to express their answer in standard form.

Question 7 (standard / high and high demand)

07.1 This question was answered well by the majority of students, with 68% giving a correct answer. The most common error was to give only one of the products, usually potassium chloride.

07.2 Although this historically is a well-known area of the specification, lack of precision in answers cost some students greatly. 16% of students achieved all three marks, with 72% gaining some credit.

The electrons are not (all) closer to the nucleus in chlorine – the **outer** electrons are. The relevant force of attraction is between the **outer** electrons and the **nucleus**, and is not intermolecular, magnetic or gravitational. Attracting another electron is not the same as **gaining** it.

07.3 This was another difficult question with 51% of students gaining no marks at all. 9% of students achieved all three. Few described the structure correctly. ‘Simple covalent’ only refers to the bonding; the structure needed to be described as small molecules, as in the specification, or as simple molecular (to distinguish it from large molecules or giant structures).

Some answers started well, referring to weak intermolecular forces, but then moved into talking about breaking bonds, for example ‘it has weak intermolecular forces so little energy is needed to break the bonds’. Again, language was an issue, with statements such as ‘hydrogen chloride is a covalent bond’ failing to gain any credit. Some students stated that hydrogen chloride is ionic (but often then referred to intermolecular forces), or did not refer to hydrogen chloride at all, instead couching their answer in terms of hydrogen and chlorine.

07.4 This question was answered well, with 73% students achieving three or four marks.

It was often difficult to give partial credit as working was difficult to follow. Many students worked out the sum of the bonds broken as 1841 kJ/mol, but then said that the sum of the bonds made was 1602 kJ/mol rather than (1602 + X) kJ/mol. Many students then calculated their final answer based on energy change = bonds made – bonds broken, rather than the other way round.

Some students missed out on putting brackets around their (1602 + X) in their overall expression, making it incorrect. A decent number divided the bond enthalpies by 2 then subtracted one from another to get the difference, which they then added to another halved bond energy. This perhaps shows a misconception that the bond energy is associated with an atom rather than a bond.

Question 8 (standard / high and high demand)

08.1 42% of students could answer this correctly. A hazard was asked for, and it was expected that students would use the correct chemical term for such a hazard; hence the idea that chlorine or carbon monoxide is **toxic** was required. Many did not use the correct term, referring instead to it being harmful (incorrect – it can kill, not merely make one ill), or dangerous or deadly (in what way?). Some students misread the equation and referred to carbon dioxide.

08.2 40**%** of students achieved the mark here. Many did not realise that their observations of a vigorous reaction with a small piece of sodium in the lab would be magnified enormously on an industrial scale. Hence the reaction would be **very** violent or explosive, not just vigorous.

08.3 There were many good attempts at this question, with 73% of students scoring at least one mark. Many students referred to the lack of reactivity of the metals with argon, but some forgot to refer to air. Then some students did not express themselves clearly, referring to one or both metals reacting with air in general, or even with gases not present in the air, such as hydrogen.

08.4 There were some excellent attempts at this difficult question, which discriminated well. 8% of students achieved full marks with 43% achieving at least one mark. Full credit could be gained by those who started with the premise that titanium chloride must be ionic so should have a high melting point; very few started from the true situation, which is that titanium chloride must exist as small molecules as its melting point is low.

The mark that was scored least often was for the explanation of the bonding and how it leads to the actual, or predicted, melting point. Some spoiled an otherwise good description of ionic bonding by also referring to ‘strong intermolecular forces’. Many referred to ‘strong electrostatic forces’ but failed to mention that those forces were between ions.

A significant number of students answered solely in terms of the separate elements, particularly titanium, rather than the compound.

08.5 51% of students achieved the mark for this question. Whilst the definition of oxidation in terms of electrons is well known, the question asked why **this** reaction is oxidation. So, it was necessary to refer to the sodium atoms losing electrons rather than giving a generalised answer. Some students referred to ‘it’ losing electrons, without specifying what ‘it’ referred to, while others referred to oxygen, which is not present.

08.6 54% of students achieved the mark here. It was not uncommon to see ‘$-e^-$’ on the right hand side. A significant number of incorrect responses showed the formation of a doubly charged sodium ion.

08.7 This difficult unstructured calculation tested a new area of the specification, and discriminated very well. 74% of students were able to achieve at least one mark, usually for calculating the M_r of $TiCl_4$. 7% of students achieved all four marks, with 12% achieving at least three marks and there were some valiant efforts.

Common errors were:

- using 92 instead of 23 to calculate the number of moles of Na
- omitting the unit conversion from kg to g for the mole calculations
- using the 1:4 mole ratio incorrectly or not at all.

Also, it is not appropriate to leave answers in the form of a fraction, even if this is the default on their calculator. Answers should always be converted to decimal form.

08.8 This was well answered, with 74% of students achieving both marks. A few forgot the 100 in their expression and didn't realise they were making about 1000 kg more than the theoretical maximum.

Question 9 (standard / high and high demand)

09.1 46% of students could explain the idea of a strong acid correctly, but few could articulate the idea of a dilute acid using correct scientific ideas. Most referred either to a low concentration (which merely expresses the opposite of the word dilute) or adding water, explaining the word diluted rather than dilute. To gain the mark, the idea of few particles per unit volume was required. Some students tried to explain the ideas in terms of pH, failing to realise that pH is itself affected by both the strength of an acid and by its concentration.

09.2 This question, on a new area of the specification, was answered well, with 68% of students giving the correct answer.

09.3 This question discriminated very well. The highest-attaining students gave excellent answers, with clearly set out working which was easy to follow. 20% of students achieved full marks, and 41% were able to achieve at least two marks, usually for calculating the correct average titre from concordant results.

Some working was very hard to follow, making it difficult to give partial marks. This was particularly the case when students wrote numbers around a pair of triangles rather than giving a step by step process. It is as important to communicate how the answer is obtained as it is to get an answer. It is also hard to follow working when partial answers are left as fractions bearing no relation to the actual data; a calculator display should always be converted to decimal form for intermediate steps as well as the final answer.

Some students had a correct answer but then took their final answer down to one significant figure. Having done a required practical, students should know that titration is a very accurate technique so that an answer to one significant figure would never be appropriate.

09.4 There was little understanding of the reasons for using different apparatus to measure the two volumes. Answers often did not mention volume at all but referred vaguely to ‘amount’ or ‘how much’. Both a pipette and a burette measure accurately and precisely – the difference is that a pipette can only measure one single volume, but a burette measures variable volumes.

09.5 32% of students achieved both marks. The most common errors were to forget to divide by 1000 when calculating the number of moles, or to calculate the mass per dm^3 but not then scale to 30 cm^3.

Use of statistics

Statistics used in this report may be taken from incomplete processing data. However, this data still gives a true account on how students have performed for each question.

Mark Ranges and Award of Grades

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