Examiners' Report
Principal Examiner Feedback

Summer 2023

Pearson Edexcel GCE
In Chemistry (8CH0)
Paper 01 Core Inorganic and Physical Chemistry

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Introduction

Candidates were able to demonstrate good knowledge and understanding on this paper. There were a number of unusual questions on this paper, which discriminated candidate performance well. The six mark question, however, was relatively standard, and although the answer required logical thought, candidates have probably seen a similar question before. This therefore proved to be accessible to all, with very few candidates scoring 0 marks. Nevertheless, it was sufficiently challenging to provide a good range of marks.

Q01

(a) This multiple choice question proved to be the most accessible question on the paper.

(b)(i) Many candidates knew that the orbital was spherical. Some gave the shape of a p-orbital, normally describing it as a dumbbell but the most common incorrect answer was circular or a circle. This presumably is simply a result of seeing the shape of the orbital in books or on a screen. Models might be a help in resolving this misconception.

(b)(ii) The idea of opposite spin was well known. Incorrect answers included travelling in opposite directions, rather than having opposite spin, or answers related to different subatomic particles, for example the charge of protons and electrons.

(c) Candidates often find calculations centred on isotopic and relative atomic mass relatively straightforward, and this was the case here, with about 75% scoring both marks. There were a couple of different approaches other than the one in the mark scheme, but all were able to score marks. Very few candidates were penalised for using unreasonable numbers of significant figures, most giving an answer to match the values in the question, i.e., 2 significant figures.

(d) The final item in this question was also well answered. The most common mistakes were to give the element as silicon or to have a mass number of 25, or both. The mass number required all seven particles, four protons and three neutrons, to be removed leaving 21, whilst the atomic number needed just the four protons subtracting. An atom with 10 protons is a neon atom.

Q02

(a)(i) This question proved more challenging than expected. Candidates most often scored the mark by answering that the substance was not a molecule. The idea that giant structures require the use of the relative formula mass was clearly not well understood. Of course, molar mass calculation can be carried out without this knowledge. Common incorrect answers included comments about the mass being relative to $1/12^{th}$ of the mass of carbon-12, the answer to the next item.

(a)(ii) The answer here was better understood. The idea of comparing to the mass of a $1/12^{th}$ of atom of carbon-12 was quite well known and there were ideas that the mass was a relative mass or a comparison. Some candidates realised that the units would cancel and scored the mark in this way.

(a)(iii) The multiple choice questions was mostly answered correctly, with over 85% of candidates scoring this mark.

(a)(iv) Whichever answer was given in (a)(iii) candidates were still able to score by calculating the correct number of moles here. For those who knew the calculation to do, which included most candidates, the only common error was to use only one significant figure, which did not score the mark.

(b) Testing for the metal ions using flame test proved to be commonly understood, with most scoring the first mark for the lilac flame of the potassium ion, and many knew that the magnesium ion did not give a flame colour, with candidates often stating that the wavelength associated with the transition was outside of the visible region. Unfortunately, it was common for answers to talk about potassium and magnesium rather than their ions. This was penalised if comments were made about magnesium giving no flame colour. Magnesium metal, of course, burns with a very bright white flame and so the omission of the word 'ions' was penalised here. The addition of hydroxide ions proved less well known, though many candidates did recognise the magnesium hydroxide would precipitate. It was quite common for candidates to discuss the lilac flame and the magnesium hydroxide precipitate without mentioning the negative tests, even though that was specifically asked for in the question. Candidates should read the questions with care.

(c)(i) Just over half of candidates were able to score this mark.

(c)(ii) Ionic equations continue to be something which would benefit from further study. This equation, which is quite commonly asked as it is one of the tests for ions which needs to be known, was not well understood. There were many attempts at full equations. Some candidates did not register that state symbols were required. Although it was possible to score the mark for answers in (c)(i) for options A and B, this was very rarely scored, firstly because these were not often selected, and secondly because the ionic equation was less straightforward, due to the difference in charges on the ions.

Q03

(a)(i) Approximately 75% of candidates were able to give B as the correct answer.

(a)(ii) Approximately 50% of candidates scored the mark.

(a)(iii) The most common mistake was to have on dative covalent bond from a bridging bromine and the other from a terminal one. Candidates could still score for having pairs of electrons in all the bonding environments and the correct numbers of lone pairs. Some candidates who focussed only on the bonding pairs of electrons so could not score the second mark. The majority of candidates scored 2 marks on this item.

(a)(iv) Incorrect responses here included the use of incorrect symbols, e.g., P or Fl. Some answered by keeping the fluorine as a pair, e.g., $Pt(F_2)_3$. Others included the oxidation state in their answer. Overall, however, this was relatively well answered.

(a)(v) Empirical formula calculations are a good source of marks on AS papers, with most candidates able to carry these out successfully. Again, there were some approaches which gave the correct answer which did not follow the route in the mark scheme, but these were able to score full marks. It is vital, particularly on calculation of inorganic empirical formulae, that all working is shown, as these formulae can often be deduced or guessed. Full marks cannot be scored on these items without working.

(b)(i) Common errors were to talk about the bond enthalpy rather than the bond strength. Full marks here required an understanding that the bond enthalpy and the bond strength were linked.

(b)(ii) This reaction, the displacement of a halide of a less reactive halogen by a more reactive one, is commonly tested both at this level and at GCSE. The idea here, to see if candidates could describe the practical techniques as well as the observation and equation for the reaction, proved a very challenging one. Many candidate reacted the solid halide with chlorine gas, failing to realise this really needs to be in solution to be effective. The use of bromine and potassium bromide as an intermediate halogen, though not required by the mark scheme, was able to score full credit. The shear amount of work to describe two tests rather than one and give the correct observations to establish the relative reactivity of iodine and chlorine made this approach harder, however.

Q04

(a) Metallic bonding is reasonably well understood at this level with almost all candidates scoring the second mark but the significance of the structure, the giant lattice of positive ions and sea of delocalised electrons, was sometimes not discussed.

(b) This calculation was well understood, and the correct value was often obtained, but the significant figures were very often not considered. There are two aspects to this, firstly the mathematical significance which candidates are now quite good at realising, but also the significance associated with the concept. In this case measuring a volume of concentrated acid to more than one decimal place is not practical.

(c) A different way to ask a question about hazard warning labels proved quite challenging. All four possible answers were given. The correct answer was scored by only 14% of candidates. This meant that one or more of the alternative answers proved more popular than the correct answer, as candidates, very sensibly, rarely leave multiple choice questions blank.

Q05

(a) This question was correctly answered by just over half of candidates.

(b) The majority of candidates either know the trend in electronegativity or used their data booklets to look up the trend in the values. Explanations often included comment on both the significant features of increasing distance from the nucleus and the increasing shielding, with many candidates quite rightly comparing these to the increasing charge on the nucleus. This was not required by the mark scheme for this item, but it was good to see. The concept of effective charge is still used quite regularly, but is still quite a difficult idea to get correct and some candidates would have been better to stick to a more straightforward approach.

(c) Continuum of bonding has not often been examined quite as directly as it was in this paper, and candidates, perhaps because they had not seen this type of question before, found the wording of their answers quite challenging. There were many different approaches to the answer including those in the mark scheme. Some candidates were able to score one mark, but scoring two marks on this item was rare.

(d) Selecting appropriate examples of the idea of continuum of bonding from the available data proved quite difficult, with few candidates scoring all three marks. The idea that sodium chloride and magnesium chloride were metallically bonded was disappointingly common. Silicon tetrachloride was quite commonly thought to be a giant covalent structure, presumably confused with silicon dioxide or with silicon itself, even though it has a very low melting temperature. Identifying the properties of aluminium chloride as the intermediate structure was the biggest challenge. Those that did recognise the types of bonding present did not always say how these were demonstrated in the available data.

Q06

(a)(i) This scored extremely well.

(a)(ii) While many candidates generally understood what was required from this question, the answers sometimes lacked clarity and precision. Iodine was often described as the reducing agent, though iodine is the product of the oxidation so cannot possibly be the reducing agent. The mark scheme allowed for the answers to be iodide ions or the sulfur as the reducing and oxidising agents when the best answers would be the iodide in potassium iodide and the sulfur in sulfuric acid as the reagent is the whole compound in which the atom/ion doing the oxidising or reducing is contained. The question specifically asked for a description in terms transfer of electrons as it followed on from (a)(i) but many candidates chose to answer in terms of changes in oxidation number. This only allowed access to one of the two marks.

(b) This question proved very challenging. Quite a good number of candidates were able to get off the mark with either the correct products or a description of the disproportionation of the bromine molecules. As far as the equations were concerned HBr was a common product, even though the reaction was carried out with sodium hydroxide and so would immediately react with it. This could not score. NaBr was also a common product, which although it was allowed made the production of balanced equation almost impossible. This question involved an ionic equation which, as mentioned earlier, continue to provide great challenge at this level.

Q07

(a) A disappointing proportion of candidates drew diagrams of covalently bonded molecules. A few drew the correct electronic structures but swapped around the charges on the ions. Surprisingly only 65% of candidates were able to draw this straightforward dot-and-cross diagram correctly.

(b) The main challenge here was to recognise that the three smaller ions were isoelectronic, and then deduce their relative size based on the number of protons in the nucleus. Some candidates relied heavily on their knowledge of the change in ion size down a group, which of course worked well in identifying bromide as a larger ion than chloride ion, and across a period. This gave those candidates a good chance of recognising the relative size of calcium and potassium ions but was not helpful with comparing these to chlorine and bromine. As mentioned earlier the idea of effective charge is a difficult one, lacking clarity and explanation, and generally was not helpful in this question. The best candidates, however, gave very clear and well written answers which clearly explained the relative sizes of the ions.

(c) This question scored well.

Q08

This question was based upon the ideas of Core Practical 1, to measure the molar volume of a gas.

(a)(i) Decreasing the concentration of the acid proved to be by far the most common correct answer. The idea of using a weak acid, which is used in this experiment in the Core Practical 1 activity did not appear as often as expected in the answers, though some candidates used a less reactive acid the nitric acid, which we allowed as being equivalent.

(a)(ii) Those candidates who knew that the calcium carbonate (or the acid) could be put in the conical flask in a separate container most often scored both marks. Only a few did not replace the bung and then mix the reagents somehow.

(b) The use of a gas syringe was the most often point to score a mark. Bubbling with carbon dioxide to saturate the water in the trough was seen on occasion. Addition of calcium carbonate to the water to saturate with carbon dioxide was commonly seen, but since we had both water in the trough and acid in the reaction it was assumed that this was the water they were adding it to, not the acid, and this would not have been effective. Quite a good number of candidates scored at least one mark, with all the possible answers in both bullet points seen.

(c)(i) Two different approaches were taken to this question. One was to read the volume of gas for a single mass of calcium carbonate, the first approach in the mark scheme. Candidates often scored two marks here, one for correct identification of the point and one for calculating the moles of calcium carbonate. Common mistakes were to use one of the points from the graph rather than the line of best fit. The second approach, finding two points and thus finding the gradient of the graph and finding the molar volume from there, was less common but tended to also score two marks with either the gradient being incorrectly calculated or the candidate not knowing how to convert to molar volume. Knowing that under relatively normal laboratory conditions the molar volume is somewhere around 22 dm^3 to 24 dm^3 was helpful in both this question and the next.

(ii) The conversion of temperature into Kelvin and the rearrangement of the equation scored quite well for candidates. Some candidates were able to then identify the need for the molar volume to have $n = 1$, and were able to get the correct answer. Most, however, used the number of moles they calculated in (c)(i) in the expression to find the volume, to find the expected molar volume for that many moles of gas. Some then divided again by the moles to give the final correct answer. Overall, relatively few candidates score full marks here.

Q09

(a) The multiple choice in (a) was scored by 70% of candidates.

(b)(i) The equation for the second ionisation energy proved to be well known. Many candidates scored both marks for both styles of equation in the mark scheme. Correct state symbols were allowed for some of the closer efforts which did not score M1, but only those that were quite close to the correct answer.

(b)(ii) This six mark question proved to be very accessible to candidates with very few not achieving at least some credit and high marks scored by many candidates. As is common for questions about ionisation energy descending a group, the idea of comparing the changes which make the value less, increased shielding and distance from the nucleus, with increased nuclear charge due to more protons, proved the least accessible indicative point out of the first four. The second two indicative points, comparing the first and second ionisation energies, were least commonly scored. Perhaps this was due to not reading the question with sufficient care, or becoming wrapped up in explaining the trend in first ionisation energy and then forgetting about this second aspect. Some marks were lost due to lack of clarity or contradictory statements about particular indicative points.

(b)(iii) For the final question of the paper, this proved fairly accessible with many candidates scoring at least one mark.

Summary

Based on the performance on this paper, students are offered the following advice:

- Reading the question with care, preferably twice before answering or once before and once after, will ensure that candidates are answering the question that has been asked, rather than one they might have been expecting.

- As is often suggested, using labels on mole calculations indicating what each calculations is trying to achieve, e.g., 'moles of magnesium chloride = 'will help both the candidate to organise their ideas and the examiner to award marks for subsequent steps after an error has been made.

- State the obvious. Be sure that important basic facts pertinent to a question, which might perhaps be considered 'too simple', are included. For example, the fact that magnesium has a giant structure and giant structures have high melting points due to large numbers of bonds. Then go on to consider the detail, in this case the detail of a metallic bond.

- Careful revision of the Core Practical activities. Questions are often set on these or very closely related practical activities. Do consider the practical aspects of why we do particular steps as these are important for a full understanding of the activity.

- Never leave a multiple choice question blank. You cannot score unless you have answered so rule out any you think are impossible and then pick one of the remaining ones.

- Try to leave time at the end of the examination to check through your answers and read the questions again.

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