Examiners' Report
Principal Examiner Feedback

January 2020

Pearson Edexcel International Advanced Subsidiary Level
In Chemistry (WCH11)
Paper 01 Structure, Bonding and Introduction to Organic Chemistry

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Introduction

Many students were well prepared for this examination and were able to demonstrate that they had a sound knowledge of the topics in the specification. Questions requiring straightforward application were generally answered well; and those set in an unfamiliar context, including several calculations, proved most challenging. A significant minority of students found the paper very challenging and would benefit from much more preparation to ensure that they know the basic facts and can communicate their ideas clearly.

Section A

The mean score for the multiple-choice section was 14.5. The highest scoring questions were Q1 and Q6 with more than 90% of students achieving these marks. The most challenging questions were Q3 and Q16, with fewer than 40% of students selecting the correct answers.

Section B

Question 18

The vast majority of students gave the correct electronic configuration for chlorine in (a), although some attempted to include 3d and 4s sub-shells. A few students gave unnecessarily complex answers, showing individual p orbitals or the arrangement of electrons in each orbital. The mark was occasionally lost for illegible superscript numbers.

From the responses seen to (b), it was clear that most students understood the definition of first ionisation energy and were able to apply this to chlorine. Some attempted to remove an electron from a chlorine molecule, however, others confused ionisation energy with electron affinity. A minority of students did not follow instruction and omitted state symbols. Most students demonstrated an understanding of the factors affecting ionisation energy in part (c), though some could not access full marks as they did not state which element has the higher value. Atomic size, number of shells and (electron) shielding were most commonly referred to, although comparisons between chlorine and bromine were not always made. Students too frequently made the same point a number of different ways (e.g. bromine has a larger atomic radius, more shells and a greater distance between nucleus and outer electron) while making no reference to the **energy** of the outer electron or the nuclear charge. Students should be discouraged from referring to effective nuclear charge as it is difficult to convey understanding through this term. Some students attempted to describe shielding in terms of electron repulsion but were often too vague to receive credit.

The vast majority of students were able to draw a correct dot-and-cross diagram for chlorine. A few lost the mark for careless mislabelling of the element symbol (e.g. using C instead of Cl) and some responses showed two adjacent chlorine atoms with no clear indication of a shared pair of electrons. There were many vague responses to (e), with students commonly referring to weak bonds or weak forces of attraction, as well as weak intermolecular forces between chlorine atoms. No comparison was to be made in this question, but many students referred to less, rather than little, energy being required to overcome the intermolecular forces. A significant number of students referred to weak covalent bonds.

The final part to this question proved most challenging. Responses to (f)(i) typically included three peaks at the correct *m*/*z* values but with incorrect ratios, or two peaks at 70 and 74 in a 3:1 ratio, demonstrating that the majority of students were unable to deduce the relative abundances of the molecular ions. Despite being told that chlorine has two isotopes in the stem to (f)(ii), a significant number of students attributed the peak to $^{36}Cl^{+}$. Where the 2+ charge was recognised, the isotopes making up the $^{72}Cl_2^{2+}$ molecular ion were not always identified.

Question 19

An wide range of responses was seen in (a)(i), with some students appearing not to have read the question and listing the metallic and non-metallic elements from Period 3. Many students seemed unsure whether the incorrectly plotted elements were Mg/Al or Cl/Ar. They were not expected to know the actual melting temperatures but should have appreciated that 600 K for aluminium contradicts its use in many everyday objects (e.g. saucepans). Similarly, a melting temperature of ~500 K for argon would make it a solid at room temperature.

Students demonstrated a good understanding of the structure and bonding in giant covalent substances with many scoring full marks in (a)(ii). Many correct descriptions of covalent bonding in terms of the electrostatic attraction between two nuclei and a shared pair of electrons were seen. Some contradiction, through reference to intermolecular forces or metallic bonds was seen and some responses lacked detail, referring to strong structures as opposed to strong bonds for example. Marks not awarded for reference to silicone, carbon or silicon dioxide; different substances to that in question.
A secure understanding of the structure, bonding and properties of metals was demonstrated in (b)(i) and (b)(ii). Marks were typically lost in (b)(i) where students lacked precision, referring to free electrons or charge carriers instead of **delocalised** electrons that can **flow**/**move** through the structure. In (b)(ii), a significant number of students incorrectly thought that the higher charge of the ion was sufficient to account for the higher electrical conductivity of aluminium.

Many students scored full marks in (c)(i), however, a large number of incorrect responses were seen, due to lack of attention to the actual question asked. Despite being told that aluminium oxide can be electrolysed in the liquid state, many covalent dot-and-cross diagrams were drawn, including a significant number for aluminium chloride. Other common mistakes included incorrect numbers of charges on ions and a partially filled shell on the aluminium ion (e.g. with one or three outer electrons). In the final part of the question, much confusion between mobile ions and delocalised electrons was evident, with many students referring to a lack of delocalised electrons in the solid or, much worse, presence of delocalised electrons in the liquid. Some lost the mark through vague responses such as ‘the ions must be free’, with no implication of movement, or a lack of depth, simply stating that ionic compounds only conduct when molten (or dissolved). Students should be discouraged from applying the word 'delocalised' to ions.

Question 20
Although most students performed well in (a), it was fairly common to see hexane presented as one of the isomers, as well as numerous C_6H_{12} cyclic and/or C_7H_{16} branched structures. Duplicate versions of the same isomer, usually 3-methylpentane, were frequently given. The most accurate responses used skeletal formulae only. Many students provided more than one type of formula for each isomer, increasing their chance of making an error, such as missing a hydrogen or including a pentavalent carbon on a displayed or structural formula.

The majority of students demonstrated a good understanding of radical substitution in (b). Marks were most commonly lost in (b)(i) from the use of double headed curly arrows, contrary to instruction. Bromine radicals were usually represented correctly, although the dots were sometimes missing and/or charges present. The propagation equations were done well by most in (b)(ii), though incorrect formulae were occasionally used despite the formula of the organic product being provided in the question. Equations were not always balanced, and students would be well advised to take greater care in the placement and legibility of subscript numbers in formulae. The alkane formed in a termination reaction was identified correctly by the majority of students, however, the **molecular** formula was not always used. Incorrect responses typically gave the formula of a bromoalkane.

The unfamiliar calculation in (b)(iv) was the most challenging part of this question with the vast majority of students failing to adequately consider the **large excess** of bromine and opting for the mono- or disubstituted products instead of the fully substituted C_6Br_{14}. Many students did not show their method clearly; doing so might have helped to prevent errors such as an incorrect bromoalkane formula (e.g. $C_6H_{14}Br_2$). The percentage by mass calculation itself posed little difficulty.

Question 21
Despite providing the conversion factor from tonnes to kg in (a), most students struggled to calculate the mass of ethene in grams. The Avogadro constant was used more competently although it was not uncommon to include an erroneous multiplication factor of six, presumably confusing the number of **molecules** of ethene with the total number of atoms. In (b), the majority of students were able to use the ideal gas equation to calculate an amount of gas. The vast majority correctly converted the temperature to Kelvin, though some also incorrectly converted the volume and/or pressure. Relatively few understood how, or attempted, to use the mixing ratio and many students also lost the final mark through careless consideration of significant figures.

The students appeared well-practised in drawing electrophilic addition mechanisms and many scored full marks in (c)(i). Needless marks were lost through careless mistakes such as imprecisely placed curly arrows, starting and/or ending in the wrong position, missing or illegible dipoles and using bromine instead of chlorine. Partial, as opposed to full, negative charges were occasionally seen on the chloride ion.

Failing to consider the rubric carefully proved an issue in (c)(ii) with a significant number of students failing to identify a hazard or listing safety goggles and a laboratory coat as precautions. The hazard was occasionally incorrectly identified as an oxidising agent and the use of a fume cupboard was a common response. In general, a lack of practical experience was evident, and some students did not appreciate that heating safely and avoiding heating are two different things.

Many students did not know how to approach the unfamiliar empirical formula calculation in (d)(i). Those who determined the individual masses of the elements involved were most consistently successful but the majority of students opted to calculate the amounts of ethene and oxygen. Where the moles of molecular oxygen were calculated, the resulting formula of $C_4H_8O_2$ was not always simplified; where the moles of atomic oxygen were calculated, the correct empirical formula was more frequently given. Some students calculated the M_r of the product but few went on to show how this was consistent with the empirical formula. Although clearly structured and labelled responses were frequently seen, many students would benefit from presenting their calculation methods more carefully.

A significant number of students did not attempt to draw a structure in (d)(ii), perhaps distracted by the redundant information about compound **Y** reacting with water; knowledge of the reaction between ethene and acidified potassium manganate(VII) is all that was required to answer the question. A few students did not give a **displayed** formula and students should be encouraged to display O–H groups when appropriate.

Students found it challenging to provide two correct **skeletal** formulae in (e), often drawing propene instead of ethene and/or buta-1,2-diene. A significant number did not attempt to answer the question or failed to read the instructions/information, using structural formulae or including additional products (eg H_2). Around half of the students scored the mark in (f)(i), with addition being the most common correct answer. A significant number lost the mark for including the word electrophilic. This reaction proceeds via the sequential transfer of hydrogen atoms to the alkene on the surface of the metal catalyst; students should be aware that not all addition reactions are electrophilic in nature. Common incorrect answers were hydration, cracking and reforming.

Phosphoric acid was commonly given in (f)(ii) though many students did not seem to appreciate the difference between reagents and conditions. The first mark was best scored through the identification of **steam**; where water was given the mark was occasionally lost for the omission of heat or stating a temperature above 400^{o}C. Incorrect responses typically gave the reagents and conditions for the hydrogenation of alkenes or the oxidation of alcohols.

The majority of students followed instruction and included a value for bond angle b in (f)(iii), with many giving an acceptable value. Some thought there was only one lone pair on the oxygen atom, giving an angle of 107°, while a few ignored the information and gave a value greater than 109.5°. A good proportion of students scored the third mark, however, many vague responses simply referring to minimum repulsion/maximum separation were seen. Only the most thoughtful and thorough students scored the second marking point as the vast majority failed to give a complete description of the electron pairs around the relevant atoms. A significant number of students misinterpreted the skeletal ring, stating three bond pairs around the central carbon for angle a.

Summary

In order to improve their performance, students should:

- read the question carefully and make sure that they are answering the question that has been asked
- write concisely and avoid making the same point multiple times
- make sure that comparisons are made when required
- write formulae and numbers carefully, checking their legibility
- be careful with the precision of curly arrows in organic mechanisms
- show all working for calculations and give final answers to an appropriate number of significant figures
- consider suitable precautions when working with hazardous substances
- make sure they understand the difference between reagents and conditions, including when catalysts are involved
- refer to both bond pairs and lone pairs when applying electron-pair repulsion theory
- reread questions and answers, where time permits, to avoid careless mistakes.

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