Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

January 2021

Pearson Edexcel International Advanced Subsidiary / Advanced Level
In Chemistry (WCH11)
Paper 1 Structure, Bonding and Introduction to Organic Chemistry

Introduction

While many students seemed well prepared for this examination and were able to successfully demonstrate and apply their knowledge of the specification content, the contrary was also observed with a relatively large number of blank responses seen for many of the questions.

Section A

The mean score for the multiple-choice section was 12.2. The highest scoring questions were Q5 and Q13 with more than 90% of students achieving these marks. The most challenging question was Q16(b), with just 26% of students selecting the correct answer.

Section B

Question 18

The large majority of students were able to complete the electronic configuration and write an equation for the first ionisation energy of sulfur. Where marks were not scored, this was usually due to pairing electrons in more than one 3p orbital in (a) and omitting state symbols in (b). Some students confused ionisation with electron affinity or electron bombardment in mass spectrometry. The majority of students failed to state the significance of all three elements having the same number of quantum shells or similar electron shielding in (c), often fruitlessly attempting to compare the shielding within the outer subshells. Students should appreciate that electron shielding predominantly arises from inner shell electrons. Most students correctly referred to chlorine possessing the greatest number of protons and while the majority attempted to explain the difference in first ionisation energy between phosphorus and sulfur, this mark was not scored frequently due to imprecise terminology, eg referring to the stability of a half-full p-orbital in the former or electron repulsion in the p-shell of the latter. The large majority of students scored full marks in (d), though some referred to species, particles or molecules instead of atoms and others did not refer to subatomic particles, answering the question in terms of atomic/mass number. Incorrect rounding occasionally lost a mark in the relative atomic mass calculation. Students were not well prepared for the mass spectrum question in (e). Very few seemed to understand the term 'molecular ion' and where students did attempt the question, many either analysed the base peak at m/z = 64 or all of the peaks, occasionally performing calculations involving the Avogadro constant. A greater awareness that the most stable ion gave rise to the base peak was apparent, though some forgot the question was about sulfur and gave Cu^+ as their answer. A minority of students indicated both a diatomic sulfur species and a 1+ charge.

Question 19

The majority of students were able to successfully complete the table in (a), the most common mistake being to omit the lone pair and/or give a trigonal planar shape. Others simply described the shape of the structure given in the question paper, giving a 90° bond angle and T-shape. Despite the comprehensive guidance provided in the rubric, (b)(i) was poorly answered with many students referring to PCl_5 as giant covalent or molecular or $SbCl_5$ as ionic. Many students attempted to explain the difference in melting temperature in terms of atomic radius, shielding, polarisability or strength of the covalent bonds. The biggest failing was that students did not use the information provided to consider the nature or the strength of the electrostatic forces involved. The large majority scored both marks in (b)(ii), though the chlorine lone pairs were occasionally omitted. A significant number of students did not use the dots and crosses as instructed and others drew very small diagrams where it was hard to count the overcrowded electrons. A wide variety of responses were seen to (c)(i) with many excellent descriptions of a dative covalent bond. Where students appeared to understand the concept but failed to score the mark, this was generally due to imprecise reference to the number of electrons involved or an implication of ionic bonding (eg one atom donating electrons to another). Many students did not seem familiar with the convention to indicate a dative covalent bond in (c)(ii). Where this was known, the arrows were sometimes shown to start at Sb or from the wrong Cl atoms. Only a small proportion of students were able to offer a reasonable attempt at part (d), with many referring to irrelevant properties of nitrogen, such as its electronegativity, diatomic structure, low reactivity, strong triple bond or low nuclear charge. Some students thought that nitrogen did not have enough outer shell electrons to form the required number of bonds, failing to appreciate the significance of its group. Those who scored the mark usually did so for stating that nitrogen could not expand its octet. Centres would be advised to teach candidates that period 2 elements cannot accommodate more than eight electrons in their outer shells as their atoms are too small and do not have any 2d orbitals.

Question 20

A failure to follow instruction meant that only a minority of students scored both marks in (a). Of those who attempted to address all requirements, a significant proportion lost the state symbols mark, giving propene as a liquid, solid or even an aqueous solution. The carbon product was sometimes incorrectly given as a gas and students did not always distinguish clearly between (s) and (g). Marks were also lost for incorrectly balanced equations. In part (b), again, many students did not follow instruction, choosing to classify the reactions and identify the products rather than describe what would be **seen**. When given, the colour changes were usually well known although some students simply stated that the colour would change and others lost a mark for incorrectly describing the colour of bromine water as red. A significant

number of students risked losing marks for the mention of effervescence or precipitate, observations that are not normally associated with either reaction. Students tended to follow instruction in (c), giving two correct repeat units of poly(propene). The mark was most commonly lost for the omission of extension bonds or incorrectly giving the structure of poly(ethene). The majority of students indicated a correct dipole on the bond in (d)(i). Credit was awarded for showing a correct dipole moment although students should be discouraged from indicating bond dipoles in this way. Some students chose to add additional detail to the diagram including electron pairs, curly arrows and electron density maps, which risked losing the mark if incorrect. Many excellent mechanisms were seen in (d)(ii) though the precision of the starting point and terminus of curly arrows could generally be improved. A significant number of marks were lost for giving chloride with a partial negative charge. Those students who gave an incorrect dipole on bromine monochloride but realised the major product is formed via a secondary carbocation should have checked that their final product matched that specified in the question. In part (e), students commonly attempted to provide more detail than was necessary, eg adding additional incorrect curly arrows, rather than being guided by where bonds were forming and breaking. Again, a significant number of students did not score marks due to poorly placed curly arrows, including arrows going in the wrong direction. The majority of students did not regenerate a hydrogen ion alongside the propan-2-ol product, failing to consider the implication of the curly arrow provided in the mechanism, or the mention of an acid catalyst in the rubric.

Question 21

Students found it difficult to suggest two properties of squalane relating to its use in cosmetics, with most referring to its long carbon chain, high boiling temperature or just repeating the information from the rubric. This question required the application of knowledge in an unfamiliar context and it was disappointing to see some students refer to the combustion properties of alkanes, citing pre-ignition, knocking and octane number for example. Most creditworthy responses generally referred to the low reactivity and/or non-harmful nature of squalane. The majority of students were able to deduce the correct molecular formula, recognising the -ane suffix and using the alkane general formula correctly. Some students attempted to count all of the hydrogen atoms, wasting time and occasionally arriving at an incorrect answer, while others ignored the carbons in the branching methyl groups. A minority of students gave what appeared to be an empirical formula. The majority of students were able to name nickel in (c)(i); acid catalysts were a popular incorrect response. Approximately half of the students scored the mark in (c)(ii) with the most common mistakes being to simply multiply the two numbers together or to divide 0.2 into 50, resulting in many non-sensical answers above 50 g. Many students were competent in their use of the ideal gas equation in (c)(iii) and were able to calculate either the number of moles of hydrogen or a

volume of squalene, though fewer could use their result to deduce the number of C=C bonds per molecule. Some tried to substitute all of the numerical data into the ideal gas equation, subsequently getting stuck when they did not know what they were supposed to be rearranging for. A relatively small proportion of students were able to use their number of C=C bonds to generate a sensible equation for the hydrogenation of squalene in (c)(iv), failing to see the connection. The majority correctly suggested fractional distillation in (d)(i), with cracking being a common incorrect answer. The unfamiliar calculations in (d)(ii) and (d)(iii) proved challenging for many, with unit conversion proving particularly problematic. Many mistakes were made in converting dm^3 to cm^3, hectares to km^2 and also in manipulating powers of 10. To prevent mistakes in unfamiliar calculations, students should be encouraged to use dimensional analysis, eg in assessing the relationship between density, volume and mass. A significant number of students did not score marks due to incorrect rounding, especially in (d)(ii), and students found it difficult to correctly use the percentage yield in (d)(iii), frequently scaling down rather than up. Most students demonstrated an understanding of restricted rotation in (e)(i) though the mark was occasionally lost for failing to mention the double bond. Some appeared confused by the two aspects of the question, thinking that restricted rotation applied only to the central C=C bond. Explaining the occurrence of only two geometric isomers proved very challenging and many students did not consider the significance of the different C=C environments or, when they did, arrived at incorrect conclusions. The best responses usually included annotation to the structure. Many good attempts at drawing the
Z-isomer were seen in (e)(ii). While the groups bonded directly to the central C=C bond were usually shown correctly, the mark was commonly lost for mistakes in atom connectivity elsewhere. Numbering the carbon atoms on the diagram may have helped students to better consider their placement. Relatively few students scored the second mark in (e)(ii) and little reference to priority groups was made. Misunderstanding of the Cahn-Ingold-Prelog priority rules was common, with many referring to the mass of the groups attached to each carbon of the C=C bond. The majority of students were able to state the meaning of the term structural isomers in (f)(i), though some forgot to refer to molecular formula or confused this with general or empirical formula. Others simply described how to write a structural formula or confused structural isomers with stereoisomers or even isotopes. A minority of students were able to deduce the correct number of geometric isomers of alpha-farnesene in (f)(ii) and very few students recognised the need for a structure with two fewer hydrogen atoms in (f)(iii). There were many blank responses to the latter and most attempts to complete the diagram resulted in either increasing the number of carbon atoms or adding multiple C=C bonds. Where just one double bond was added, the mark was occasionally lost for giving a structure containing a pentavalent carbon. Again, numbering the carbon atoms on the diagram may have helped students to better attempt this question.

Summary

Based on their performance on this paper, students should:

- read the question carefully and make sure that they are answering the question that has been asked, following **all** instructions
- consider the guidance in the question rubric (but do not repeat the information given)
- check their use of specialist terminology (eg orbital/subshell/shell)
- make sure they understand the difference between a molecular ion and a fragment ion and can identify these on a mass spectrum
- check they have a good understanding of the electrostatic forces of attraction involved in ionic, giant covalent and molecular substances
- present their work clearly
- pay careful attention to the placement of curly arrows in reaction mechanisms
- check that the number of carbon atoms, and the number of bonds, is correct when drawing organic structures
- practise unit conversion and working with powers of 10 in chemical calculations