Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

October 2022

Pearson Edexcel International Advanced Level In Chemistry (WCH15) Paper 01: Transition Metals and Organic Nitrogen Chemistry

General Comment

This paper was similar in style and standard to previous Unit 5 papers of this specification; a range of skills and knowledge was assessed and the levels of difficulty allowed good discrimination between the different grades, while allowing well-prepared candidates at all levels to demonstrate their abilities. This is an A2 examination paper and therefore had a synoptic element but, for the most part, candidates seemed better prepared for the standard questions rather than those requiring application of knowledge and understanding. Many candidates lost marks because they did not answer the question that was actually set.

Multiple Choice Section (Questions 1-18)

This was the highest scoring section of the paper with a mean score across all candidates of 52.8%. 76% of candidates gave the correct answer to question 18, while just 20% of candidates gave the correct answer to question 10, the lowest scoring question.

Question 19

Most candidates knew that the highest stable oxidation state of vanadium was +5 although many who were able to give the correct electronic configuration of the element could not link this to the oxidation state. Some candidates gave the electronic configuration as $[Ar]3d^5$ and deduced the highest oxidation state from this while others deduced the highest oxidation state to be +3, ignoring the role of the 4s electrons. A number of responses ignored the instruction to use electronic configuration and attempted explanations based on the electrode potential data.

The most common error in (b)(i) was selection of the thiosulfate-sulfur electrode system, candidates failing to appreciate that the reduction of VO^{2+} must involve the oxidation of the thiosulfate. Candidates who did identify the appropriate half-equation were not always able to write the balanced overall ionic equation. Relatively few candidates addressed the need for the reduction to stop at V^{3+}.

In (b)(ii) most candidates calculated the $E^{\ominus}_{cell}$ value for the reaction of nickel with VO^{2+}. Few candidates considered the $E^{\ominus}_{cell}$ value for the reduction of V^{3+} to V^{2+} but the significance of this value being both negative and close to zero was not well understood.

Candidates rarely used the available data in attempting (c)(ii) with many simply stating that there was no reaction between VO^{2+} and manganate(VII) ions without explanation.

The calculation in (c)(iii) produced a good range of marks. The first three marks were widely accessible but candidates found dealing with the back titration aspect of the question quite demanding and this was often omitted altogether. While most candidates appreciated that the calculation required a scaling factor to deal with the use of the 25 cm^3 sample from the volumetric flask, this was often introduced at the wrong place in the calculation. The use of the formula mass of the VO_3^- ion (rather than the atomic mass of vanadium) to calculate the mass of vanadium was very common.

The sequence required for (d) was well known by some candidates but many responses omitted the vanadium(V) oxide altogether. A significant number of equations were left unbalanced by the introduction of a charged intermediate vanadium oxide species.

Question 20

The best answers to this question were carefully structured around the guidance given in the stem, however, candidates frequently gave all they knew about the reactions of bromine with cyclohexene, benzene and phenol, including laboratory observations and mechanisms. There were many errors of detail where candidates confused addition and substitution, and electrophiles and nucleophiles, while cyclohexene often became cyclohexane or even 1,3,5-cyclohexatriene. Many candidates were familiar with the interaction of the oxygen lone pair with the delocalised π electrons of the benzene ring and with the need for a catalyst for bromine to react with benzene.

Question 21

The calculation using ideal gas equation in (a)(i) was generally completed successfully, although it was quite common for candidates to convert the gas volume into dm^3 while converting the pressure into kPa. Sometimes no unit conversion was attempted and the final answer 'corrected' at the end of the calculation.

Most candidates were able to determine the formula mass of the ring in (a)(ii) and use this to deduce the formula of R, although some forgot that R was an alkyl group and gave the formula as CH_3CO, which caused huge difficulties in the subsequent items.

In (b)(i) candidates needed to consider the two possible structures of C_3H_7 and use the NMR data to select the correct one. Many did not seem to appreciate that two structures were possible and simply assumed the straight-chain version, using the NMR data to support this.

In (b)(ii) most candidates realised that proton environment 1 was a triplet and were able to explain it but few appreciated that proton environment 3 had a third proton on the adjacent carbon atom on the ring. There was widespread use of non-standard terms to describe splitting patterns. While this practice was not penalised provided the meaning was unambiguous, it should not be encouraged. A number of candidates explained in detail why proton environment 2 was a sextet even though the question did not require this.

While the ring structure did create an extra level of difficulty in (c), most candidates were able to identify the chiral carbon atom and hence deduce that coniine would show optical isomerism. Those that did opt for cis-trans isomerism did so on the basis of a barrier to rotation about a C=C and this approach gained no credit.

Question 22

There were many correct answers to the slightly unfamiliar calculation in (a), often involving a purely algebraic approach. Some candidates failed to convert the percentage of water into a fraction and ended with a negative value for the atomic mass of M. Candidates who went wrong rarely used the information that M was a transition metal to put matters right.

Fully correct ionic equations were rarely seen in (b)(ii). The formula of the chloro complex ion was better known than that of the aqua complex with quite a number of sulfato ligands being given in the latter. Even where the formulae of both ions were correct, the equation was not always balanced.

Explanations given for the change in shape of the complex ions in (b)(iii) were often incomplete or imprecise. The link between the sizes of the ligands and their ability to coordinate around the central ion was established only rarely while use use of terms such as 'chlorine atom' or 'chlorine molecule' rather than 'chloride ion' were quite common.

Question 23

The inversion of the standard calculation of a formula from percentage mass data in (a) caused some candidates considerable difficulty but, for the most part, the determination of the molecular formula from a fairly complex structure was the most likely source of error.

The oxidation system required for (b)(i) was reasonably well known with the omission of the acid or the use of reflux being the most likely errors. Potassium manganate(VII) was the most common incorrect reagent but sulfuric acid and lithium tetrahydridoaluminate(III) also appeared.

Part (b)(ii) tested candidates understanding of the standard method of obtaining aldehydes by the oxidation of primary alcohols but most responses suggested that a temperature of 197^{o}C was too difficult to attain in the laboratory.

The mechanism for the electrophilic substitution of benzene for (c) produced some excellent answers and many candidates dealt effectively with the unfamiliarity of the electrophile although the omission of aluminium chloride was quite common. Other errors usually involved inappropriate placement of the curly arrows which were often shown originating from an atom and terminating well away from the positive carbon in the electrophile.

In the synthesis required for (d) many candidates knew that the formation of the Grignard involved the use of dry ether and were able to draw the Grignard structure. However the reactions of the Grignard reagent with thecarbonyl compounds seemed unfamilar and those that did know it often lost the mark by drawing the intermediate with a trivalent carbon or with the phenol group in the wrong place. The reagent needed to dehydrate the alcohol was not well known.

There were some excellent structures of the salen ligand complex drawn for (e)(i) showing the lone pairs and making sure the connectivity of the OH group was accurate but there were many errors of detail mainly the omission of the charge or of some of the ligand-Ni^{2+} bonds; the dative covalent bonds were often unidentified. A common error was to assume that

salen was a bidentate ligand and draw three ligands. Several candidates removed the hydrogen atom from the OH group to produce a covalent bond to Ni and many wanted the Ni^{2+} to have a coordination number of six, showing the additional bonds but not always linked to an atom.

There were few fully correct answers to (e)(ii). Candidates referred to the relative strength of the bonds in the complexes and to the stability of the benzene ring; when entropy was mentioned, the entropy of the system was rarely specified.

Paper Summary

Based on their performance on this paper, students should:

- be aware that in this examination they will be tested, in part, on their ability to apply scientific knowledge and processes to unfamiliar situations
- remember to read questions carefully, be familiar with the meanings of command words and be alert for information that might be helpful in formulating their responses
- ensure that they are answering the question that is being asked, and answering it in full
- make sure that they understand the exact significance of curly arrows in organic mechanisms and practise their use with unfamiliar compounds
- try to ensure that they use the names of different particles and groups of particles correctly (eg atom, ion, molecule, group, functional group)
- learn to consider whether the values they obtain from their calculations are chemically realistic and are consistent with other information in the question.