



Examiners' Report  
Principal Examiner Feedback

January 2023

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

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## General comments

Section A seemed accessible to most candidates, however Section B and C proved more challenging with some examiners reporting evidence of blank spaces for several questions. In question 20 this may have been due to time management, but it was evident in many of the earlier questions as well.

## Multiple Choice Questions

Section A had a mean of just under 13 marks, suggesting it was slightly more accessible than the equivalent June 2022 series.

The most accessible questions were 3 (identifying a colourless complex), 5 (calculating the percentage of water in a hydrated salt), 7(a) (identifying the role of ultraviolet radiation in free radical substitution reactions), 7 (linking catalytic activity to activation energy), 9 (calculating the number of moles of atoms in a copper sample) and 11(a) (identifying wave numbers in relation to bonds).

The most challenging questions were 1 (deducing the lowest oxidation number of a metal in unfamiliar complexes), 2(a) (deducing the overall charge in a complex), 6 (colour change of solution as  $\text{EDTA}^{4-}$  is added), 12(a) (recognition of reaction type with Grignard reagents) and 15(b) (reagents and conditions needed to form azo-dyes).

## Question 17

Part (a) proved to be an accessible opening to Section B for most candidates with just over 50% of the cohort able to score full marks. The emphasis on showing a given formula rather than deducing an unknown formula meant a wide variety of strategies could be used. Many calculated the mass of carbon, hydrogen and hence oxygen, which is probably the most useful technique, as it can easily be used even if the empirical formula is unknown. Some candidates found it challenging to go beyond calculating the amounts of water, carbon dioxide and **A**, but picked up some credit for this working.

Part (b) proved much more challenging. A significant number suggested **A** was a primary alcohol, not picking up on the importance of the iodoform reaction. In addition, it was common to see the formula of **C** given as  $\text{CH}_3\text{I}$  and candidates not appreciating **D** and **E** were alkenes, despite the clear inference from the stem.

Most who attempted the question in (c) suggested a correct structure, with a small number of correct ethers also observed. Labelling proved more difficult, either because candidates struggled to pick out different environments on the benzene ring, or they only labelled one side of the molecule.

Candidates found (d) even more difficult with less than 50% of the cohort able to interpret the mass spectrum data and link it to a structure. Those who did, were often able to justify their response in terms of fragmentation or identifying the ion with  $m/z$  ratio of 107.

## Question 18

As expected most candidates found (a) straightforward, with over 80% of the cohort correctly stating the oxidation number of vanadium in  $\text{Na}_3\text{VO}_4$ .

Few candidates managed to apply their chemical knowledge effectively in (b). Those who attempted an answer often framed their response in terms of the inability to fit six water molecules around the  $\text{V}^{5+}$  ion or its high oxidation state. A few did recognise the potential polarising power of the ion but failed to recognise exactly what species the  $\text{V}^{5+}$  ion would polarise. Very few answers made reference to the deprotonation of the water molecules.

In (c) nearly 40% of candidates were able to deduce the formula of the salt correctly. Even those who did deduce the final formula nearly always managed to calculate the ratio and hence deduce the empirical formula.

Similarly, in (d) the calculation in (i) proved straightforward for many. However using the ratio correctly in the equation in (ii) was more challenging. Only a small number appreciated the species containing vanadium with an oxidation state of +5 was  $\text{VO}_2^+$  and not  $\text{V}^{5+}$ . Others didn't use the ratio from (i) to help guide them towards the oxidation states of the products. Hence  $\text{VO}^{2+}$  was a common incorrect product.

Answers for (e) tended to fall into three categories. A number barely attempted an answer. Others clearly understood how to manipulate  $E_{\text{cell}}$  values in order to predict which reactions would and would not occur. This group often scored highly, apart from minor errors when balancing equations. A third group seemed to understand the basic ideas but didn't use the stem as guidance. For instance a number calculated all the relevant  $E_{\text{cell}}$  values and made the point that iron would reduce V(V) further than tin. However they then didn't attempt to write equations for the reactions. Others did the reverse, and deduced the relevant equations but didn't use the  $E_{\text{cell}}$  data to justify their comparisons.

## Question 19

In (a)(i) the electrophilic substitution mechanism was familiar ground for many, even with a relatively unfamiliar compound. Common slips included the arrow / electrons moving from the electrophile in step 1, leaving the positive charge on the nitro group in the intermediate and forming 4-nitrophenol as the main product. A small number, perhaps having not practiced the mechanism other than with benzene, attempted to attach both the hydroxyl and nitro group to the same carbon atom. In (ii), only a minority of students made the link between the lone pair on the oxygen on the hydroxyl group, and the subsequent increased reactivity of phenol. Those who did, often scored both marks.

The organic synthesis in (b) proved an effective discriminator for the higher grades. Virtually all candidates paid attention to the stem and did not attempt to increase the carbon chain using a Grignard reagent. A proportion of candidates didn't appreciate the need to extend the carbon chain. However a number of these did realise that an amine and an acyl chloride were required to form the final product and could gain credit for this. Others started by extending the chain by forming a nitrile using KCN.

However, a number missed a mark here by not recognising the need for an ethanolic solvent.

The majority of candidates could show the structure of the zwitterion in (c)(i). Those who missed the mark generally did so because they didn't attempt an answer or left the amine group unchanged. The structure of the dipeptide in (c)(ii) was far more challenging, with only the more able candidates seemingly up to this challenge. A number misinterpreted the question and attempted to show a repeat unit of a polymer, others attempted to draw structures with additional nitrogen or carbon atoms, often attempting to show two peptide links. This suggests a misunderstanding by some of the term 'dipeptide'. In (c)(iii) just over a quarter of candidates could work out the molecular formula. It was slightly odd to see errors in both the number of nitrogen and oxygen atoms, as well as the more difficult determination of the number of carbon and hydrogen atoms. Most candidates who attempted (c)(iv) did so successfully. A small number of otherwise sound candidates didn't attempt this straightforward question, perhaps because they didn't read the whole stem with care, and moved straight to (c)(v). In (c)(v) one of the main points for candidates to consider is the idea that hydrolysis will produce products with additional hydrogen and oxygen atoms. A large proportion of candidates didn't appreciate this and simply 'cut' aspartame into three pieces, often leaving trailing bonds with nothing attached. The calculation in (c)(vi) was competently processed by the majority, and those who didn't score full marks often got some credit via transferred errors. The most common error was the omission of a conversion for milligrams into grams. However nearly all final answers were quoted to three significant figures. Whilst this was allowable on the final mark scheme, it's worth pointing out that some of the data in the question was only given to two significant figures, so this level of precision was the most suitable in this context.

## Question 20

The electronic configurations proved to be a clear-cut start to part (a). The most common error was to fill the 4s orbital before occupying the 3d orbitals the  $\text{Mn}^{2+}$  ion. Part (a)(ii) proved tough for many and the stability due to a half-filled d subshell was recognised by only a minority of candidates. Even those who did make this link struggled to develop an argument to explain the differences in the two  $E_{\text{1}}$  values. Those who did often framed their answer in terms of a comparison between the two different elements, rather than the ions of the same element.

Nearly all candidates could deduce the relevant oxidation numbers in (b)(i) though many answers lacked precision and it was not always clear whether the change to 0 for chlorine referred to  $\text{Cl}_2$  or  $\text{MnCl}_2$  which was critical in this context. The calculation in (b)(ii) was straightforward for many, with nearly all attempted answers spotting the need to scale up from  $100 \text{ cm}^3$  to  $1 \text{ dm}^3$ . The most common mistakes were an inability to calculate the amount of oxygen from its volume or omitting to use the ratio from the equation to deduce the amount of hydrogen peroxide.

Candidates found the equation in (c) very demanding, with very little evidence of attempts to use the information in the question to construct an answer. This suggests an assumption from candidates that they should use recall rather than work it out.

In (d) Many referred to the stock definition of catalysis without reference to the graphs at all. There was a widespread misconception that  $\text{Mn}^{2+}$  ions were only acting as the catalyst in experiment 1 and not in experiment 2. Also, there were a number who concentrated on solid manganese sulfate without noticing that it had dissolved, so discussed its surface area and went on to describe homogeneous and heterogeneous catalysis. The best answers made clear reference to the role of  $\text{Mn}^{2+}$  ions as an auto-catalyst, linked their comments to key features of the graph and made it clear that no  $\text{Mn}^{2+}$  ions were present at the start of experiment 1.

Candidates showed excellent numeracy skills in (e)(i), with most candidates gaining credit. A variety of methods were used to prove the potassium manganate(VII) was in excess, including comparison of masses, moles and showing the ratio was greater than 2 : 1. On a few occasions answers were left without a valid comparison at the end. In (ii) most could suggest a suitable reagent to form the acid, but a few wrongly suggested it was a hydrolysis reaction.

Only a small number of candidates could construct the half-equations in (f)(i), though around a third did get some credit for recognising the role of Zn and  $\text{MnO}_2$  as reactants at the correct electrode. Just over half the cohort could calculate the standard electrode potential in (f)(ii), with +2.71 V the most common incorrect attempt.

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

- read the information given in all parts of a question carefully, noting any instructions given in bold type
- very few questions expect you to just know the answer – expect to have to use your prior knowledge or information in the question to make sensible suggestions, trusting the chemistry
- practice writing equations for a range of redox reactions in both acidic and alkaline conditions
- in longer written answers use the guidance in the stem to make sure your response covers all the points demanded by the question
- practice deducing the products of formed when esters and peptides are hydrolysed



