Examiners' Report
Principal Examiner Feedback

January 2025

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

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General comment

The majority of candidates had clearly prepared well for this paper and were able to apply their knowledge of the topics in the specification to familiar and novel situations resulting in a mean mark of 53. However, it appeared that a number did not seem to have a good basic understanding of complex ions, organic bases, the electronic configuration of transition metals and their ions and the interactions of ions with water molecules. However, generally, calculation questions were done with impressive accuracy and there was no evidence of candidates running out of time.

The mean mark for the Multiple Choice, Section A, was 14.

The most accessible multiple-choice questions were 8 (standard electrode potentials) and 15 (polyamides) and the most challenging questions were 12 (deducing the formula of a hydrocarbon from combustion) and 2 (transition metal colours)

18(a)(i) The majority of candidates scored well on this opening question. However, many did not read the information carefully enough and failed to state the concertation of the solutions and identify the compounds required. Most correctly selected a suitable compound for the salt bridge with KNO_3 being the most popular answer, but very few mentioned that the solution should be saturated or concentrated. Identifying platinum as the electrode, B, was almost as well-known but occasionally zine, iron or graphite were seen. In part C, the question asked for the compounds that could be used in the right-hand half-cell and it was expected that candidates would give answers like iron(II) sulphate and iron(III) sulphate. However, this was rarely seen, with most simply giving Fe^{2+} and Fe^{3+}, which was allowed on the mark scheme this time. The concentration of these solutions appeared slightly less well known and concentrations other than 1.0 mol dm^{-3} were often seen.

18(a)(ii) The function of the salt bridge was not well understood, with few candidates realising it was to allow ions to flow through it. A number thought that a wire was not used as it would react with the chemicals in the beakers and some stated that electrons would flow through the salt bridge, neither of which gained any credit. A number appreciated that the salt bridge allowed the charges to balance, but failed to explain how this was achieved.

18(b) The equation was well done and there were very few errors in charges, balancing and direction. Occasionally, the equation was reversed and a few candidates gave a cell diagram or two half equations, none of which scored. A significant number used a reversible sign in place of a direction arrow, but this was not penalised.

18(c) Although there were a number of excellent well-presented explanations to this question, they were not the norm. Most candidates realised this was an equilibrium question but some did not make it clear which reaction they were referring to. Many appreciated the zinc equilibrium would shift to the left and so make the zinc electrode more negative but were then often not able to link this to the change in the E_{cell} value.

Answers were roughly equally split between a decrease and increase in the E_{cell} value, with a few opting for no change. A very small number of candidates simply referred to non-standard conditions which gained no credit.

19 Candidates showed an excellent knowledge of this reaction sequence with many achieving full marks and the mean was just over three out of six. Most correctly identified the reducing agent for step 1, but some forgot the dry ether or added another reagent, both of which negated the mark. All of the available answers to produce a halogenoalkane in Step 2 were seen, with KBr and H_2SO_4 the most popular. The most common mistake was using the oxidising agent potassium dichromate and acid. Most candidates who selected the right reagents for Step 2, usually identified a correct structure for X, but in some cases a carbon was missed off or the halogen did not match up with their reagent(s) in Step 2. There were few mistakes identifying the Grignard reagent but where they were made, most involved the wrong number of carbon atoms. The use of carbon dioxide for Step 4 scored quite well and many candidates. mentioned the use of an acid too. However, the best answers pointed out that hydrolysis had to take place after the addition of the carbon dioxide. This is important as there seemed to be a general lack of understanding that both $LiAlH_4$ and Grignard reagents are susceptible to reaction with water and so anhydrous conditions are necessary.

20(a)(i) Many candidates were able to select and use the information correctly from their Data Booklet and write the correct equation. However, a significant number wrote down the half equations, but did not combine them accurately and it was common to see uncancelled hydrogen ions, water molecules and electrons. Rather oddly, hydrogen peroxide was often omitted from the equation which meant no marks could be awarded and occasionally the equilibrium sign was seen where an arrow should have been but this was not penalised.

20(a)(ii) This was well answered by the majority of candidates as they generally found it straightforward to select a suitable metal and calculate the E_{cell} value. Occasionally, a correct metal was selected but the E_{cell} was not calculated or a mistake was made in the calculation. A few incorrectly selected a wrong metal with aluminium, silver and manganese being the most common and some chose metals that were not in the data book despite the instructions in the question.

20(a)(iii) Many candidates knew the reaction was ligand exchange, but the identity of the complex ion proved to be more problematic. The most common near miss was where only four ammonia molecules were replaced.

20(a)(iv) This proved to be one of the more straightforward questions on the paper with the majority of candidates correctly stating it was not a redox reaction and giving the correct oxidation numbers. However, some calculated the oxidation numbers incorrectly and others chose not to use them at all, despite the request in the question.

20(b) Rather surprisingly, deducing the simplest formula of the salt proved to be quite challenging to many candidates and a wide range of different formulae were seen. Where the correct formula was given, most candidates were able to calculate the number of moles of water correctly and many answers were well set out with both marking scheme methods seen in similar numbers. For those who made a mistake with the initial formula, transfer error marks were applied, with many scoring full marks for the calculation. Unfortunately, a few lost the final mark for not giving the number of water molecules as a whole number.

20(c)(i) This slightly novel calculation proved to be quite challenging with over half of the candidates failing to score any marks as many seemed unable to make a logical start. Those candidates who were successful used a variety of approaches to this calculation, but failure to convert g dm^{-3} to g cm^{-3} was the most common error.

20(c)(ii) Although most candidates realised that EDTA was a hexadentate ligand, many struggled to explain the significance of this reaction to chromium poisoning. Answers that compared the coordination numbers or stated that less EDTA was needed or that the EDTA bond to the chromium ion was stronger were too vague to score. Although the mark scheme gave credit for a variety of answers for the second mark, most scored it the for the increase in entropy, rather than the stability of the complex.

21(a)(i) Although most candidates gave the correct arrangement of electrons in the Fe^{2+} ion, a significant number thought the 4s orbital would remain occupied.

21(a)(ii) The oxidation of iron(II) to iron(III) was well understood, although a number of candidates did not use the word oxidation so lost a mark. There were some good explanations of why the oxidation reaction took place, either in terms of the stability of a half-filled *d* sub-shell or the instability of a doubly occupied orbital. However, many candidates did not score due to a lack of precision as they failed to distinguish correctly between orbitals, sub-shells and shells. A number also gave a general description of the origin of colour which was not required.

21(b) It was clear that the majority of candidates had an excellent understanding of this redox titration with over half of them scoring full marks. There were a number of the usual mistakes such as using 25.0 cm^3 instead of 17.0 cm^3, not multiplying by 5 or by 10 or failing to give the final answer to 2 or 3 significant figures.

21(c) This proved to be one of the most challenging questions on the paper and a lack of understanding of complex ions was apparent in many answers. Very few candidates appreciated that the iron(II) sulfate formed a complex ion with water and that the that the acidity was due to its deprotonation. Many incorrect answers had the sulfate ions reacting hydrogen ions to make sulfuric acid or water simply losing protons.

22 This six-mark question was well answered by many candidates and the mean mark was almost three.

IP1 appeared to be quite challenging as some candidates thought the two mechanisms were different, others missed out electrophilic and just said substitution and some did not mention any mechanism. A few nucleophilic substitutions were also seen.

IP2 scored well with many candidates giving the full mechanism instead of just the required equation. However, the product, dibromobenzene was quite a common error, which negated the IP.

IP3 proved to be more challenging as although most candidates realised that three bromine atoms were substituted onto the benzene ring, balancing proved problematic for some. Although there was no requirement to name the product, if it was given, it had to be correct or the IP was not awarded and this caught a few candidates out.

IP4 was often scored and it was frequently shown in the equation for IP2.

IP5 was most commonly scored for simply saying phenol does not require a catalyst or the reaction occurs at room temperature. However, some answers were too vague as statements such as just ‘requires milder conditions’ did not access the IP.

IP6 was well known with the majority of candidates accurately describing the increased reactivity of phenol. However, a number did not specify that it was the oxygen lone pair (of electrons) that was responsible for the increased reactivity and a variety of near misses were seen.

23(b)(i) About half the candidates correctly identified both reagents for this reaction, but some lost marks by using chloroethane instead of chloromethane. Occasionally the generic chloroalkane or halogenoalkane were also noted, neither of which scored.

23(b)(ii) This mechanism, including the generation of the electrophile and regeneration of the catalyst was well understood and large numbers of totally correct, well-presented answers were seen. However, there were the usual errors associated with curly arrows not starting or ending precisely in the expected positions. In particular, the curly arrow from the methylbenzene ring going to the oxygen, instead of the nitrogen of the NO_2^+ and the return arrow from the C-H bond originating from the hydrogen atom, not the bond. Other common errors included the methyl group being absent or in the wrong position and not giving an equation to show the regeneration of the sulfuric acid catalyst.

23(b)(iii) The majority of candidates were able to correctly identify the reagent for this reaction, although marks were sometime lost due to the incorrect connectivity of the OH group. Classifying the reaction type proved to be more challenging with nucleophilic substitution being the most common incorrect answer. Most of the candidates who scored this mark did so by identifying the reaction as condensation rather than the expected esterification.

23(c)(i)-(ii) This question was found to be particularly challenging with over one third of candidates failing to score any marks. However, those who applied their knowledge of amine chemistry to this novel molecule were able to gain credit.

In (c)(i) many candidates could describe how the lone pair of electrons on the aryl nitrogen atom got incorporated into the benzene ring but they often then failed to relate this to the strength of the base. The electron donating effect of the alkyl groups appeared to be less well known but once again this was often not linked to the availability of the lone pair and strength of the base.

The quality of diagrams in (c)(ii) was generally poor as very few candidates appreciated that the hydrogen ion bonded to the procaine with a dative covalent bond. Rather surprisingly, when the hydrogen ion was bonded correctly it was often to the wrong nitrogen atom as it contradicted their answer from (c)(i).

23(c)(iii) This was the most challenging question on the paper with only a quarter of the candidates gaining any credit. The majority simply discussed intermolecular forces, particularly hydrogen bonding and compared the strength of the interactions with water. Those who did identify the procaine hydrochloride as being ionic, often did not seem to appreciate why it was more soluble in water. The hydration of the ions by water did not appear to be understood and most candidates who scored the second mark accessed it by saying it was an ion-dipole interaction which was allow in the mark scheme.

23(d) This final calculation, like most of the others on the paper, was particularly well done and half the candidates scored full marks. Where a mark was lost, the most common mistake was to miss out multiplying by the Avogadro constant in the final step.

In order to improve their performance, students should:

- always read the information in the question carefully, noting the command word and follow the instructions given
- show working when carrying out calculations, think carefully about units, significant figures and rounding and check the legibility of your work
- practise converting between different units
- practise reaction mechanisms, paying particular attention to the origin and destination of curly arrows
- learn and be able to explain the variations in basicity of aliphatic and aromatic amines

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