Examiners' Report
Principal Examiner Feedback

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

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Introduction

This paper provided a full range of marks. Some candidates were clearly very well prepared and scored very high marks. Calculations were generally well answered with a number of candidates providing very well laid out answers which were easy to mark. Questions directly related to the content of the specification points, demonstrated by explanations and descriptions, clearly showed that many candidates had acquired this knowledge. Items requiring application of this knowledge were less successfully answered, however. It would benefit candidates to have unusual contexts presented to them in their preparation so that they can practise applying their hard-earned knowedge and understanding. Shortage of time did not appear to be an issue, with large numbers of candidates successfully completing the final question with few blank answers to this item.

Section A

The mean mark for the multiple choice questions was 11.2.

The questions the candidates found easiest were 1(c) and 2(b) with over three quarters of candidates on average scoring these marks.
8 and 12a were the most difficult of the questions. 1(b), 3, 4 and 9 also proved difficult, with less than half the candidates scoring these.

Section B

Question 13

The structure of benzene and its derivatives is often examined in this paper. Here the evidence supporting the delocalised structure rather than that proposed by Kekulé was considered.

In (a) the results of X-ray diffraction experiments needed to be applied to the structures. For both marks to be scored a comparison had to be made between the actual result and how it linked to each of the structures. It was commmon for candidates to remember that the bond lengths between carbon atoms shown by these experiments were the same, thus linking the results to the delocalised structure, but less common to say that the double bonds in Kekulé's structure would be shorter than the single bonds. Many candidates simply said that the bond lengths were the same rather than different without explaining the source of this difference. As a result most candidates scored 1 mark

It was anticipated that many candidates would attempt to answer (b) using diagrams, so a space was left in the answer region for them to do this, and many did. Those that did found it much easier to score both marks as without a diagram describing accurately the two different structures was challenging. Candidate should see spaces such as that at the top of the answer space in this question and consider whether either a diagram, a calculation or an equation would help them in answering the question. This question proved difficult for candidates with a relatively low percentage scoring well here.

The answer to part (c) most often involved a calculation (perhaps in the space left below the lines) all though many correct answers were given with no calculation.
13(d) can also be answered using a diagram which is commonly found in revision resources. Many candidates tried to reproduce this, but the diagrams were often not of the best quality. Also diagrams needed to be labelled or explained in the text and this explanation, particularly of the sigma bonds between carbons, was often missing. A significant number of candidates answer this question using hydridisation theory. This is not a requirement of the specification, but for many it clearly helped their understanding, while part (e) compared it to the synthesis of paracetamol from phenol. This part proved much more challenging than expected.

Question 14
The synthesis of two different painkillers was the basis for this question. Parts (a) to (d) focussed on the synthesis of *N*-phenylethanamide from benzene in a three step synthesis from benzene.

In (a)(i) the second reagent, other concentrated nitric acid, for the formation of nitrating mixture, and the electrophile formed in this mixture were required. Concentrated sulfuric acid was often given, but a number of candidates did not include the concentration of the acid and so did not score this mark. The electrophile was sometimes forgotten. Candidates really must read questions with care. Fortunately it was possible to score this mark if a correct electrophile was given in the mechanism in (a)(ii). This mechanism is now well understood by many candidates, and with no substituents already on the benzene ring there was less confusion. Many candidates scored all three marks here. Overall this proved the highest scoring of the parts in Sections B and C.

The reduction of nitrophenol to phenylamine in (b) was well known and understood. Having penalised candidates for omitting concentrated from the sulfuric acid, we did not do so here if it was omitted from the hydrochloric acid. Tin is the most acceptable metal for this reaction, although one or two others which can also be used were seen. These were well answered by all candidates, with

(c) was the extended response question on this paper, and proved to be accessible to most candidates. The best answers recognised the importance of particular hazards such as the toxicity of hydrogen chloride and ethanoic anhydride and the flammability of ethanoic acid, while discounting the hazards of ethanamide and *N*-phenylethanamide as being common to both reactions. Some candidates answered at great length about hazards but then did not respond to the part of the question asking about atom economy. Those that did often scored one of the two indicative points because they failed to justify the lower atom economy using ethanoic anhydride. This was sometimes because they stated that ethanoic acid was larger or heavier than hydrogen chloride without providing evidence in the form of their molar masses or an atom economy calculation. Many candidates spoke about the reactivity of the two starting materials, with many recognising the significance of the rate of reaction, but some thought that a higher rate would give a greater yield and a greater yield would mean a higher atom economy and therefore did not score that particular indicative point. While six marks was quite uncommon it was unusual for a candidate who attempted an answer to score 0 so the full range of marks were seen. The mean mark on this question was 2.44 and the most common score was 3.

The calculation in part (d) was quite well answered with a number of candidates making a start on the answer and therefore scoring some marks. Candidates with a good idea of what to do generally scored very well. The maximum mark of 4 was the most common mark here, with the next most common being 1 mark. Some candidates tried to do some calculation but clearly were not sur how to proceed and scored 1 mark.

The relative reactivity of phenol compared to benzene was well understood by many candidates, with answers given that were consistent with those on previous mark schemes for this relatively common question. Some candidates failed to mention the complete description of the electrons as a lone pair of electrons from the oxygen and so lost one mark. Just lone pair is not sufficient. A very significant minority of candidates described the electrons as a 'long pair'. I am not sure where this might have come from but I have not seen it often before and I hope not to see it again!

Question 15

This question was concerned with the chemistry of compounds in ginger. It included an extended four step synthesis of zingerone from coniferyl alcohol via a Grignard reagent.

Part (a) considered gingerol, a compound found in fresh ginger. The molecular formula for this compound is challenging to work and (a)(i) fully tested the candidates understanding of skeletal formulae. In (a)(ii) the significance of the wedge-shaped bond shown in the structure was recognised as either due to the chiral carbon it was attached to or as way of showing that it was in a plane in front of the paper, but relatively few candidates recongnised the significance of both and so scored only one mark.

The four step synthesis in (b) was laid out in a way that candidates would not have been used to, but which seemed to give many of them somewhere to start from, either trying to move forward from coniferyl alcohol or backward from zingerone. There were three common routes taken by the successful candidates which can be seen in the mark scheme. Care needed to be taken that the oxidation to an aldehyde was not done using reflux, which would result in the formation of some carboxylic acid. Also the absence of dry ether in the step using a Grignard reagent was also penalised. Sulfuric acid needed for the oxidation was also sometimes missing, although we did allow acidified potassium dichromate(VI). Many candidates completed the intermediate structures on the right hand side of the equations and then copied them on the the left hand side. Provided one was correct we did not penalise small slips on the other with such a large and complex structure. If only one intermediate structure was given, which was the intention, we did not mind whether it was on the right hand side of one equation or the left hand side of the next. The question gave a full range of marks.

Question 16

The application of electrode potentials and reduction and oxidation of manganese compounds was tested here in the format of a Latimer diagram. This unusual context did not appear to through off too many candidates who were able to apply their knowledge well in some parts of this question.

Part (a) tested the use of Latimer diagrams to predict the feasibility of reactions between different oxidation states. In (a)(i) many candidates were able t ojustify the oxidation of manganese as =%. Many did this by calculation rather than logic which was a perfectly acceptable approach. The equation in (a)(ii) was challenging for many, although the three manganese species were often written correctly so 1 mark was scored. The best approach was to write two half-equations for the two separate processes and then combine them to form the overall equation. The information that the reaction was carried out in acidic conditions meant some candidates put H^+ on the left hand side of the equation, not realising that the manganese species is itself an acid, and hence not being able to balance the equation as far as H^+ and water were concerned. The deduction of feasibility in (iii) was well understood, though some who knew the answer did not score the second mark by omitting a comment that the calculation gave a positive result and that it was this that made it thermodynamically feasible.

Part (b) centred on the titration of sodium ethanedioate using acidified potassium manganate(VII). In (i) surprisingly few candidates were able to give the correct colour change. Some gave the change the wrong way around, others gave a change involving colour suggesting the use of methyl orange indicator, some gave colour changes suggesting the use of starch as an indicator. This item proved far more challenging than expected. The calculation in (ii) was done extremely well by some candidates. There were very many methods used to achieve the result, with a number of different steps which could be carried out in different orders. The most common errors included use of the wrong ratio of manganate(VII) ions to ethanedioate ions, or ignoring the need to use one. Other mistakes included using the 25cm^3 and 250 cm^3 volumes to generate a factor of 10 to be used in the calculation, when in fact both these volumes were used with the same mathematical process so they did not give a factor of 10 at all. The factor of 10 is a common feature when 25cm^3 of solution are taken from volumetric flask which contains 250 cm^3, but that was not the case here. Some candidates were able to lay out the calculation clearly, labelling the expected outcome of each step, while for others the answer space was scattered with apparently unlinked calculations. Candidates should be encouraged to be as clear as possible, so it is easy to award marks for processes correctly carried out in the calculation, even if the final answer is incorrect. Part (iii) was not well answered, with relative few candidates being aware that a manganate(VII) titration will give manganese dioxide as a product if insufficient acid is present. Some of those that did clearly used the Data Booklet as suggested to provide information regarding the numbers of electrons transferred and hence the effect on titration volume.

Section C

Question 17

This sole question in this section was based upon isomerism in transition metal complexes. It presented information in novel contexts and so required a good understanding and application of the candidates knowledge. As expected this section generally provided the most challenging questions.

In (a) isomers of chromium(III) chloride were considered. In (i) the source of colour in transition metal complexes is commonly asked in this examination, but candidates seemed to be put off by the slightly different approach in this question. Many recognised that different colours resulted from absorption of energy of light from different wavelengths and frequencies, and so leaving different transmitted colours. This gave one mark, but the other two marks, which were to explain how this occurred in the complexes, was rather harder for candidates to score. Many knew it was something to do with splitting of orbitals in the d-subshell, but their answers lacked clarity and accuracy. Many candidates said that the ligand caused the d-orbital to split. Candidates must be made award that the d-orbital is a singular thing and cannot split, and that it is d-orbitals (plural) which split. It might be best to focus answers on the splitting of the d-subshell (singular) into two sets of orbitals. Candidates also found it hard to describe precisely how the light was then absorbed by electrons being promoted from a lower to a higher energy level. A significant number also incorrectly thought that light was emitted as electrons went back to the lower energy levels, which is true for flame test colours but not for coloured transition metal complexes. As a result the mean mark for this question was just over 1. Part (ii) was a question where one or two marks were quite easily scored, by addition of an excess of silver nitrate solution, but the remaining three were more challenging. A full range of marks were scored here by candidates who recognised that the use of silver nitrate to precipitate the free chloride ions was the secret to this practical. This discriminated well at the higher grades.

The cis-/trans- isomerism in platin was the focus of (b). This has not often been asked about and so required application of knowledge. Of the three parts (ii) proved the most straightforward. In (i) many candidates missed the positive charge from the platinum complex, while others got the correct charge but had removed one of the ammonia ligands as well as the chloride ligand. This slip was less common where candidates gave a structural formula drawn out, rather than in the form of $[Pt(NH3)_2(H_2O)Cl]^+$. Many candidates recognised that a lone pair would be the key to the answer in (ii) but some did not accurately describe where it was. In (iii) the trans- orientation was often recognised as the key feature to this answer but it was difficult to award marks on occasion as the description of the fact that the dna strand was on the opposite side to the second chloride ion was often not clear.

The empirical formula calculation in (c) was an interesting twist to this familiar calculation. Many candidates were able to score the first two marks but were unable to then recognise the numbers of each type of ligand in the complex and hence draw a correct structure in (ii).
The final part, (d), was a relatively straightforward finish to the paper, with many candidates scoring at least 2 marks from the three available. Though a different question there were some similarities between (i) and 15(a)(ii) in that they were focussed on a chiral centre, in this case a cobalt metal rather than the more normal carbon atom in 15(a)(ii). In the same way this question tended to score 1 of the 2 marks as candidates either recognised the cobalt atom was a chiral centre, or that two optical isomers must be two non-superimposable mirror images but not often did they recognise that both must be true, one for each mark. I had expected that the answer to (ii) might prompt the second of these, but although very many candidates scored the mark in (ii), often by drawing very clear mirror images, sometimes even including a line to show the mirror plane, they did not often relate this to the previous answer.

Summary
Based on the performance in this paper students should:

- Read the question with care. Underlining or highlighting key words can be helpful in the structuring of answers. This is particularly important for questions which seem very familiar to the candidate. They may be familiar and just what the candidate expects, but it may be a different one so it is best not to assume.
- Practise questions in unfamiliar contexts to gain familiarity in applying their chemical knowledge and understanding.
- Layout calculations clearly, labelling what each calculation is attempting to achieve. This helps to clarify thinking and makes it easier to see opportunities for markers to award marks for carrying forward an error correctly later in the calcuation, so scoring by transferred error.
- Be given opportunities to attempt questions or activities involving the selection of appropriate data, either from a question such as the extended response question here, or using the Data Booklet, for example in the formation of equations.
- Practice deducing molecular formulae from skeletal structures.
- Be exposed to carefully prepared model answers showing the correct use of technical terms such as orbital and orbitals, subshell and subshells etc..

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