



Examiners' Report

Principal Examiner Feedback

October 2019

Pearson Edexcel International Advanced
Subsidiary Level

In Chemistry (WCH05)

Paper 01 General principles of Chemistry II –
Transition Metals and Organic Nitrogen
Chemistry (including synoptic assessment)

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Introduction

The paper provided an opportunity for candidates to demonstrate their knowledge of chemical principles and to apply them in a range of situations. There were both straightforward questions requiring recall, set in familiar contexts, and more challenging questions where candidates had to analyse and use data.

Candidates were often successful at combining half equations (Question 20(d)) but struggled to write their own half equations (Question 20(c)).

They performed well when calculating percentages by mass and using combustion data (Questions 21(e) and 24(f)) but had difficulty in explaining trends in ionisation energy, bond lengths and the meaning of delocalization applied to electrons. The organic mechanism in Question 24(b) was often answered well, but many candidates showed weakness when answering questions using skeletal formulae (Questions 24(a), 24(c) and (d)).

Multiple Choice

The multiple-choice question with the highest score was Question 1, and the second highest was Question 16.

The multiple-choice question with the lowest score was Question 12, and the second lowest was Question 5.

Question 20

(a) The question directed candidates to use the Data Booklet, but it seemed that many did not know what to look for. The first mark was for choosing a metal which is above manganese in the table of Standard Electrode potentials. The second mark was allowed for a balanced equation even if the chosen metal was one which reacts with water at room temperature. However, some candidates selected elements for which no data was available.

(b)(i) Many candidates were not sure how to set up a cell to investigate a particular reaction and did not score all four marks. Platinum was the common correct answer for the electrode, but answers frequently suggested using manganese or a hydrogen electrode. Many different compounds were suggested for the salt bridge; compounds which would react with the solutions in the beakers cannot be used. The question asked for substances **C** and **D** to be identified and, while many candidates correctly gave the name or formula of a compound, others identified only the ion.

Answers suggesting both manganate (VII) ions and manganese(II) ions were allowed one of the two marks for **C** and **D**.

(b)(ii) Nearly all candidates correctly chose the two half equations involved and then were able to calculate the correct value.

(c) This question caused difficulty and was frequently left blank. The equation in the question was often just rewritten without the potassium ions. When a half equation was attempted, it was often not balanced and electrons were missing, or added to wrong side. Many candidates did not seem to realise that charges have to be balanced as well as entities.

A common incorrect answer was $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$

(d)(i) Candidates who could not write half equations were more successful here by selecting the relevant half equations in the table and combining them. If they did not show their working, they were more likely to make errors in balancing, but many answers were correct.

(d)(ii) This was usually answered correctly.

Question 21

This was a straightforward question for many. The error which occurred most often was an incorrect electron configuration of copper.

(b)(i) Deducing the electron configurations of copper and zinc is an essential step before answering this question. However, it seemed to make many candidates think that the most important factor affecting the magnitude of ionisation energies was whether there were one or two electrons in an orbital. Some argued that ionisation was easy if there were two electrons in an orbital because they repelled each other. Others argued ionisation was difficult because full orbitals are stable. Many used one argument in (b)(i) and the other in (b)(ii).

Few answers made the most important point which is that zinc has one more proton than copper. Many knew that electrons are removed from the 4s orbital in each element though they did not say so directly. Few candidates seemed to have considered the factors that cause a change in ionisation energy across a Period, which are increase in nuclear charge, the energy level of the electron being removed, and changes in shielding.

(b)(ii) In this part, most candidates earned a mark for stating that the second electron in copper is removed from a 3d orbital, but then tried to give a reason based on whether the orbital was full or not and this did not score the second mark.

21(b)(ii) Many candidates lost marks here by careless use of language. A common answer was to refer to the filled 3d orbital of zinc, rather than to a set of filled 3d orbitals or the sub-shell. Many also thought that the 3d orbitals are not split by ligand molecules, rather than saying that there is no space for any transitions from lower to higher energy levels. There was some confusion with production of colour by excited electrons in atomic emission spectra.

21(c)(i) This was straightforward recall of experimental results and many candidates knew that the colour was blue in both cases, but they did not always say that the solution was a darker blue than the precipitate.

21(c)(ii) This was often well attempted, and many scored the mark for the correct complex ion. Marks were lost when either the charge was missing from the complex, a common mistake, or when the equation was not balanced, usually by leaving out the hydroxide ion which conveniently meant the charges were then balanced. A common incorrect complex was $[\text{Cu}(\text{NH}_3)_2(\text{H}_2\text{O})_4]$ with or without a charge.

21(d)(i) The term “amphoteric” was known by a large proportion of the candidates.

21(d)(ii) This equation was a lot more demanding than the complex formation in question 21(c)(ii). Candidates had to work out that the white precipitate was zinc hydroxide as well as giving the formula of the product with hydroxide ions. Answers including water ligands were allowed on this occasion.

21(e)(i) This equation should be familiar to candidates and was made easy by the reaction ratio being given. However, many candidates did not know the formulae of the products. Errors included using I^{2-} , no charge on the tetrathionate ion, using S_4O_8 (with or without a charge), IO_3^- , SO_4^{2-} and many different compounds containing various proportions of iodine and sulfur.

21(e)(ii) This calculation was familiar and generally well done. It was disappointing to see good answers losing a mark by missing the instruction to give the answer to three significant figures. Other errors included use of the atomic number instead of atomic mass to calculate the mass of copper. A surprisingly common error was to calculate the mass of copper and then subtract it from 3.50 before finding the percentage.

Question 22

22(a) This question was very low scoring despite being apparently simple. The most common response was that delocalised electrons are electrons which can move. This could just be a description of electrons moving round a nucleus, so the mark was not given without the idea that electrons are not fixed in one bond or can move from one bond to another. The term “not fixed in one position” was allowed.

22(b)(i) Candidates are very familiar with drawing a circle or part circle inside a benzene ring rather than double and single bonds to indicate the extent of delocalisation. Not many answers applied this principle to show that a carboxylate ion has two delocalised bonds rather than a C=O and a C-O. Various different ways of showing the delocalised structure were accepted.

22(b)(ii) Deducing bond angles using electron pair repulsion theory was introduced in Unit WCH02 and apparently forgotten since then. The question was poorly answered. Surprisingly, the ion was often drawn with angles of 120° but followed by an answer stating the angle was 120° .

22(c)(i) Candidates are generally very good at describing bonding in benzene, but either did not read this question carefully or did not understand what was required. Answers to the number of delocalised electrons were from three to twelve. The orbital from which they originate was often named as a pi orbital instead of a p orbital.

22(c)(ii) Again candidates did not read the question carefully or did not understand what is meant by a physical method. Carrying out a reaction with bromine shows that the bonding in benzene differs from bonding in alkenes, but this is not a physical method and does not give direct evidence for delocalisation. X-ray diffraction is the method which shows that the carbon-carbon bond lengths are all the same.

22(d) Candidates are very familiar with the idea that the lone pair of electrons on the oxygen atom in phenol interacts with the delocalised ring and they often explained that this makes phenol more reactive than benzene with electrophiles. This question was not about the reactivity of phenol. It asked about the bond length of the C-O bond in phenol which is shortened because the electron density between C and O is higher than in methanol. Many answers said that the electron on the oxygen was attracted to the delocalised electron cloud which is not correct.

22(e)(i) There was evidence that candidates returned to this question after answering Question 22 (e)(iii) as there were a lot of crossings out of sulfuric acid. On this occasion the formula of nitric acid was allowed as an alternative to the name but the word “dilute” or a sensible practical value for the concentration had to be given. A few candidates gave a percentage value for the concentration. This is not normal laboratory practice and should not be encouraged.

22(e)(ii) This question scored less well than expected mainly because of careless mistakes. There were diagrams without the OH group or missing the aromatic ring, use of NO_3 or NH_3 for the nitro group,

formulae which were mirror images, drawings with the second structure just upside down, mixing two different structural isomers such as a di- with a tri-nitro compound and so on.

22(e)(iii) This was generally well answered. To score the first mark it had to be clear that both acids need to be concentrated. The condition was often given as “heat” or “reflux” which was not allowed without a temperature or range being given. A temperature “less than 60°” was not allowed as this is not necessarily more than 50° and similarly a temperature “more than 50°” could be much too high. A range of incorrect reagents was given, the most common being reagents for diazotization or reduction of nitrobenzene.

Question 23

23(a) A common answer simply said, “they form hydrogen bonds”. This does not on its own provide an explanation, and a comment about the atoms which formed the hydrogen bonds was required. For the second mark there had to be a comment about why the hydrogen bond formation improved solubility. The alternative answer was based on amino acids as zwitterions and the interactions they could form with water. A small number of answers referred to internal hydrogen bonding of amino acids and missed the point about interactions with water.

23(b) This was not very well known, and a large number of compounds were suggested.

23(c)(i) This was straightforward for candidates who knew the general formula of naturally occurring amino acids.

23(c)(ii) The reaction with phosphorus(v) chloride indicates the presence of an OH group so the amino acid **Z** must contain an OH as well as a COOH group. Several isomers exist with formula $C_3H_7NO_3$ but not all fit the general formula of a naturally occurring amino acid. Candidates could score 2 marks for one of the incorrect amino acids if it had an OH group and the chiral centre was correctly labelled.

23(c)(iii) There were two possible structures for the dipeptide depending on whether amino acid **Y** or **Z** used its COOH group in the peptide bond. The correct peptide link had to be shown for a mark and transferred error marks were allowed if incorrect structures for amino acids **Y** and **Z** were used correctly.

Question 24

24(a) Many errors were seen. Some candidates tried to name the compound. Others tried to give a structural formula. An incorrect number of carbon atoms was given with about the same frequency as an incorrect number of hydrogen atoms.

24(b) This mechanism is familiar to many candidates. Despite this, some forgot to include the equation for the formation of the electrophile. Drawings of the intermediate were often careless. The horseshoe showing partial delocalisation should cover at least three carbon atoms but not the tetrahedral carbon, and the positive charge should be within it. Extra δ^+ charges were often dotted around the formula. The new bond forms from carbon in the benzene ring to the carbonyl carbon atom, and a common error was to show the ring connected to the oxygen, or to the CH_3 in the alkyl group. The curly arrow leading to the loss of the H atom from the tetrahedral bond should come from the bond, not the H atom. Marks were lost when the mechanism is not shown accurately, so care is needed.

24(c) Information about the aldol condensation was given in the passage and this is what candidates had to use to answer this question. Many made the mistake of including two C=O bonds in the product.

24(d) Candidates who noticed that the reaction was one where the product had a longer carbon chain than the starting material could use the hint in the passage that hydrogen cyanide was involved. However, many seemed unfamiliar with the cyanohydrin reaction. Another difficulty may have been that candidates are not confident using skeletal formulae.

24(e)(i) Most candidates were able to give an appropriate drying agent with (anhydrous) calcium chloride being the most popular. However copper sulfate and, to a lesser extent, cobalt chloride were often given. A suitable reagent to absorb carbon dioxide was not so common. Lime water and soda lime were both allowed but heat, plants, limestone, sodium carbonate and various pieces of apparatus did not score. If candidates give a list of their suggestions which includes an incorrect answer, they will not score the mark.

24(e)(ii) In past examinations candidates have shown that they can find the percentage of oxygen in an organic compound by subtracting the percentages of other elements from 100. What they could not do in this question was to put into words that this method is used because the oxygen in the combustion products could come from both the organic compound and the air. It was disappointing to see answers at this level which had nothing to do with the masses of the elements, for example “impurities may be present”, “oxygen may evaporate”.

24(f)(i) This was a routine calculation and nearly all candidates scored at least one mark. A few did not know the difference between an empirical and a molecular formula and lost a mark either here or in question 24(f)(ii).

24(f)(iii) The use of language was important here. The mass/charge ratio of the line furthest to the right gives the value of the relative molecular mass. The mass/charge ratio of the highest peak on the spectrum is not necessarily the heaviest fragment. Stating that it is the mass/charge ratio of the molecular ion does not answer the question of how the relative molecular mass can be found from the spectrum.

24(f)(iv) The majority of answers suggested testing with bromine. These answers often said it was decolourised but did not refer to the white solid. Incorrect reagents included phosphorus(V)chloride, Brady's reagent, sodium dichromate and many more.

24(f)(v) Many correct structures were shown but unfortunately the hydrogen atoms causing the singlet and triplets in the nmr spectrum were not always marked. Candidates who did not read the question carefully thought that the phenolic OH was the cause of the singlet.

Paper Summary

Advice for candidates:

- Make sure you know the difference between an ionic equation and a half equation.
- Practise writing half equations and check that they are balanced in species and charge.
- Practise explaining chemical ideas; it may be helpful to break an explanation into a series of small steps. For example, when explaining differences in ionisation energy, think about what factors affect ionisation energy and the effect of each on particular elements.
- Don't give a list of possible answers if only one is required.
- Become familiar with using skeletal formulae.

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