



Examiners' Report Principal Examiner Feedback

January 2019

Pearson Edexcel International Advanced 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

A wide range of achievement was shown in this paper. Most candidates found it accessible and some excellent work was seen. In other scripts, significant numbers of questions were not attempted. Some questions required explanations in which points had to be given in a logical order, and candidates often lost marks in these. The calculations on this paper involved series of steps, and it was often difficult to follow what a student was doing.

Section B

Question 19

Most candidates knew that platinum was required for both electrodes in Q19(a)(i), though some suggested iron and manganese.

Q19(a)(ii) was challenging for many candidates. Many failed to recognise that the 1 mol dm^{-3} solution of iron(III) sulphate contains 2 moles Fe(III). A majority thought (incorrectly) that mixing equal volumes of two 0.50 mol dm^{-3} solutions would produce a 1.0 mol dm^{-3} solution. One mark was awarded for a method which produced a solution which was equimolar with respect to iron(II) and iron(III) ions, and the second mark was awarded for saying that the mixture should be 1.0 mol dm^{-3} with respect to each ion, or for saying it should be equimolar with respect to each ion. Candidates forgot that the concentration would be halved when equal volumes of solutions were mixed. Many also referred to the concentrations of the iron compounds and not to the ions. Some did not read the question and discussed hydrogen electrodes and standard temperature.

Many correct answers were seen for Q19(a)(iii). The most common errors were to suggest insoluble manganese compounds such as manganese oxide or hydroxide. In Q19(a)(iv) a common mistake was the use of iron ions, and hence a green precipitate and iron, or its ions, appeared in the equation.

Q19(a)(v) and (vi) were straightforward and both answered well. However, Q19(b)(i) caused difficulty. It was about a reaction in which a solution of sulfur dioxide reduced iron(III) ions, but many candidates selected data about a half cell in which the solution of sulfur dioxide, which contained H_2SO_3 , was oxidised. The second mark in the question could still be gained if it was clear that the cell involving the reaction of H_2SO_3 with Fe^{3+} ions had a positive E_{cell} value. The question said that electrode potentials should be used, but some answers did not include any data. It was often unclear whether candidates were writing about standard electrode potentials of half cells or cell potentials for the overall reaction as the symbols E , $E_{\text{electrode}}$ and E_{cell} were used interchangeably.

The calculation in Q19(b)(ii) gave a wide spread of marks. Nearly everyone calculated the number of moles of manganate(VII) ions correctly for the first mark.

After this some went wrong when using the mole ratio of $1 \text{ MnO}_4^- : 5 \text{ Fe}^{2+}$. Many calculated the number of iron(II) ions correctly but then multiplied this number by the relative atomic mass of iron, rather than calculating the number of moles of Fe_2O_3 and using the molecular mass of the compound.

In Q19(b)(ii) the half equations for the oxidation of iron(II) ions by dichromate(VI) ions were in the Data Booklet and did not have to be shown. Many candidates gave the correct final equation without writing down the half equations and scored both marks, but other candidates failed to combine them correctly or used equations for iron(II) being reduced to iron. The final part of Q19 asked for a practical reason for the preference of potassium manganate(VII) in titrations but answers varied widely with suggestions about cost, toxicity, oxidising power and rate of reaction and these did not gain marks.

Question 20

Few candidates used the information in Q20(a)(i) which told them that the products included a copper compound formed by reduction of copper(II) sulfate, and few candidates helped themselves by using the half equations to construct the final equation. This resulted in few correct answers. The copper salt was often given as copper(II) iodide, and the element copper, Cu, often appeared as a product. There were many correct answers to Q20(a)(ii) showing the configuration of a Cu^+ ion, despite CuI appearing infrequently in the equation. A wide variety of suggestions for another ion with the same configuration was seen in Q20(a)(iii).

Many candidates found it difficult to express the answer to Q20(b) clearly. It was common to see answers about a single d orbital splitting, and this was not allowed. The appearance of colour was confused with the production of coloured light in flame tests, with answers describing electrons being excited and then emitting energy as light. It was often not clear that the colour that was seen depended on the frequencies which had been absorbed when the electrons were excited, and comments such as "so light is reflected" were not good enough for the third mark.

The shape of the hexa-aqua copper(II) complex ion in Q20(b)(iii) was well known, and many candidates deduced that three molecules of 1,2-diaminoethane would be present in the complex in Q20(b)(iv). The diagrams did not always show that the bonds were between the nitrogen atoms and the copper. The equation in Q20(b)(v) required care, especially if it was written with HCl rather than chloride ions. This caused mistakes in balancing, but again a correct shape was often given.

Some candidates referred to "disproportionation" when they should have written "deprotonation" in Q20(b)(vi) but most knew that the second step of the reaction was an example of ligand exchange. Errors in the formula of the complex ion of copper(II) ions with ammonia were seen regularly and these included NH_4 for ammonia and OH instead of water, as well as mistakes in the number of each ligand and the charge. Many candidates scored both marks in Q20(b)(vii) as they

distinguished the precipitate and the solution, and made clear that the solution was a darker blue than the solid.

The explanation in Q20(b)(viii) had to be in terms of entropy, and answers were often difficult to interpret. Some candidates focused on change of state which was not relevant, as both reactions formed a solution at the end. Some compared the number of particles of reactant and product including the complex ions; others just considered the number of ligands displaced. It had to be clear that there was an increase in the number of particles of product in the formation of the diamine complex, and this had to be compared to the formation of the ammonia complex. The statement "there are more products with 1,2-diaminoethane" is not clear enough. This first point leads to the idea that the entropy change of the reaction, which can be called the entropy change of the system, is greater when the diamine complex forms. This leads to a greater increase in the **total** entropy change and a higher equilibrium constant for the formation of the diamine complex. In their answers, the symbols S , ΔS , ΔS_{system} and ΔS_{total} appeared to be used interchangeably. The increase in ΔS_{system} was often not stated explicitly. The equation showing the relationship between the total entropy change and the equilibrium constant was sometimes quoted but not applied.

Question 21

Nearly all answers to Q21(a) referred to X-ray diffraction providing evidence that the carbon to carbon bonds in benzene are all the same length, contrary to the Kekulé theory. However very few answers explained that a Kekulé structure could give rise to 1,2-dichlorobenzene with either a C=C or a C-C between the two carbon atoms attached to the chlorine and isomers with these structures are not known.

Answers to Q21(b) showed that candidates had not read the question. Many wrote at length about how the delocalised electron pair on the oxygen atom affects the benzene ring, but the answers did not state the conditions and products of the reactions as asked. Few stated that phenol reacts with bromine water. Many thought that benzene would be substituted with two bromine atoms, but scored the mark for the catalyst. Answers referring to the addition reaction of benzene often named the product as hexabromobenzene or gave the formula as C_6Br_6 instead of $C_6H_6Br_6$. Many failed to give the correct conditions for addition.

The mechanism in Q21(c) was well known and many candidates scored all four marks. A few Kekulé benzene mechanisms were seen, and occasionally a confused combination of Kekulé and delocalised mechanisms. The curly arrow going from the C-H in the intermediate was wrong more often than the one from the ring to the electrophile, and the equation for the formation of the electrophile was quite often missing.

The wavenumber range in Q21(d)(i) was often given correctly. Sometimes one value within the range was suggested, but this was not allowed. The equations for

the polymer production in Q21(d)(ii) were also an improvement on recent answers. The main source of error was to draw a dimer, or not use n monomer molecules in balancing.

Section C

Question 22

In a proportion of answers to Q22(a)(i) the identity of compound **A** had obviously been deduced as the correct reagents and conditions, were there but the identity of **A** was missing. The temperature was the condition most often missing. The reagents needed to reduce the nitrobenzene in Q22(a)(ii) were often given correctly.

The formula of *N,N*-dimethylphenylamine was given in the passage, but a significant number of answers to Q22(b) showed the methyl groups substituting on the benzene ring rather than on the nitrogen atom, and many forgot to balance the equation.

The temperature required for Q22(c) was also well known, even though quite a few answers suggested refluxing at 5°C . In this part of the question there was occasional confusion between nitrate and nitrite.

Most candidates recognised the amide group in the formula of carbutamide in Q22(d)(i), though both the amine group on the benzene ring was suggested, and the NH in the chain.

To work out the molecular formula of benzocaine in Q22(e)(i) the student had to be able to interpret the skeletal formula. Surprisingly, even the number of oxygen atoms in the molecule was sometimes incorrect. A structural formula without the molecular formula was not accepted. A problem arose in Q22(e)(ii) when candidates gave a formula showing the benzene ring as a hexagon. They often showed the fragment made from the benzene ring and the NH_2 group as if it was phenylamine, whereas the fragment is $\text{C}_6\text{H}_4\text{NH}_2^+$ (or $\text{C}_6\text{H}_6\text{N}^+$). Some answers showed the fragment $\text{C}_6\text{H}_4\text{COO}^+$ with a negative charge, and this was not allowed.

The organic products of the hydrolysis of benzocaine in Q22(e)(iii) could be shown as structural or skeletal formulae, but if skeletal the H atoms in the OH groups had to be shown. Many candidates worked out that ethanol would form, but recognising the formation of aminobenzoic acid was more challenging.

The first part of Q21(f)(i) asked candidates to calculate the mass of oxygen in 100.0g of procaine. This was the key part of the calculation. However, many candidates calculated the number of moles of carbon dioxide and water produced by combustion and then did not calculate the mass of carbon and hydrogen in these compounds. Some candidates calculated the mass of oxygen in the carbon

dioxide and water and wrongly thought it all came from procaine. Those who did calculate the masses and number of moles of the four elements did not always use the fact that there are 13 carbon atoms per molecule of procaine. There are alternative methods to deduce the formula and these were allowed. Even if they could not solve the calculation, candidates could have looked at compound **Y** in the passage and seen that it contained 9 carbon atoms. Procaine contains 13 carbon atoms, so the formula of the two alkyl groups attached to the right hand nitrogen atom could be deduced.

Summary

Based on their performance on this paper, candidates should

1. State what you have found in each step of a calculation. This should help you keep track of what you are trying to work out.
2. In a calculation about the mass of atoms do not stop when you have calculated the number of moles.
3. If you are asked to **use** data, you should quote the values you have used to reach your conclusion.
4. Questions often contain information which will help with the answer. Always read the question carefully, and do not assume it is the same as one you have seen previously.