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Examiner Report / Principal Examiner Feedback

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IAL Chemistry WCH05/01

Unit 5: General Principles of Chemistry II

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Grade Boundaries

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General

This paper was similar in content and demand to the closely related 6CH05/01 and 6CH05/01R of the 9CH01 Advanced level specification (2008). The paper proved accessible to well-prepared candidates offering good opportunities for them to demonstrate their knowledge and understanding. However, only the better candidates were able to apply their knowledge in unfamiliar contexts and few demonstrated a secure appreciation of the experimental aspects of the subject. There were quite a number of examples of errors which clearly arose from a failure to read the question fully or with sufficient care.

Multiple Choice Section (Questions 1–20)

The multiple choice questions provided a range of demand for the candidates at the different grade levels. Most candidates (87%) answered question 3 correctly while just 10% overall gave the correct response to question 16, rising to over 40% for candidates around the A grade boundary. As with the structured questions, the ability of candidates to apply their chemistry to unfamiliar situations was at a premium.

Question 21

Most candidates were able to retrieve the relevant equations for 21(a)(i) and 21(a)(ii) with very few selecting the manganate(VII)- manganate(VI) half equation and fewer still giving reactions in alkaline conditions. Writing the overall equation proved a testing exercise with candidates experiencing difficulties in balancing the reaction while uncancelled water, hydrogen ions and electrons were common although only the last were penalised. Calculating the E_{cell} value was by no means straightforward, the most common error being to reverse the sign of the (1.23 V) E^{o} value and then subtract this negative value from 1.51 V.

While there were many excellent descriptions of the preparation of a standard solution, the majority of candidates seemed unfamiliar with the procedure. Many described dissolving the solid in the volumetric flask and the use of a conical flask for the entire process was not uncommon; more reasonable attempts often omitted the use of distilled water and the transfer of washings to the solution. A significant number of candidates describe a titration procedure or the preparation of Mohr's salt.

Many candidates were unable to correctly describe the end-point of the manganate(VII)-iron(II) titration, sometimes reversing the colours but often simply giving incorrect colours. 21(b)(iii) proved a good discriminator, with common errors being the use half-equations involving iron metal or the inclusion of electrons in the final equation.

Only the best candidates solved the problem in 21(b)(iv) using a method that demonstrated a clear grasp of what was required. Many started from the premise that the concentration of manganate(VII)-in the titre was 0.02 mol dm^{-3} and, while it was possible to work from this to the correct answer, more frequently it led to the calculation of a mass of Mohr's salt greater than 10 g. Far too many candidates approached the calculation without any clear goal, calculating various quantities; these attempts usually just tailed off without conclusion. In practice the item discriminated at all major grade boundaries.

Question 22

The identification of the species and reagents required in 22(a)(i) and (ii) discriminated effectively at the major grade boundaries and correlated well with overall attainment on this paper. When candidates showed a reasonable grasp of the chemistry involved, marks were frequently lost through relatively simple inaccuracies in details such as the number of ligands present or the overall charge on a complex. While there were quite a number of fanciful responses to 22(a)(iii), most candidates appreciated that ethanal was a reducing agent in this reaction but far fewer correctly identified the organic product, many suggesting a range of copper species. Relatively few candidates seemed familiar with the use of iodine formation and titration with standard thiosulfate as a means of estimating copper ion concentrations, even though this is one of the practical examples quoted in the specification.

22(b) should be familiar ground but the explanation for colour in transition metal complexes still discriminated between candidates with a clear understanding of and those relying on imperfect recall of a learned response. At the upper end some candidates gave excessive detail involving descriptions of ligand field splitting, while, at the other extreme, candidates described emission spectra or uneasy combinations of both processes. Reference to the splitting of a d orbital and omission of the idea that the colour is due to the remaining frequencies were common errors. The explanations of the different colours of different complexes were less clear, with one or other of the marking points being omitted or candidates suggesting that a change of oxidation number was involved.

While many candidates scored full marks in 22(c), there were a number of common avoidable errors. In 22(c)(i) omission of the state symbols and failure to balance the equation were surprisingly frequent and in 22(c)(ii) many candidates simply gave the general definition of disproportionation.

Question 23

Most competent candidates calculated the empirical formula successfully, setting out their method very clearly. Typical errors did occur, including the use of atomic numbers, relative molecular masses and inappropriate rounding. The most common error in 23b(i) was the identification of $m/e = 44$ as the molecular ion, although these candidates often scored the second mark. Many candidates gave the molecular formula without explanation and lost the mark for 23(b)(ii). Many of those who did attempt an explanation gave the M_r of the compound as 90, rather than 89.

Candidates at all levels scored well on 23(c). In 23(c)(i) the mark for the explanation of the amine was the least likely to be awarded with candidates typically just repeating the statement that the solution darkened or identifying the resulting complex as an ammine. Most candidates suggested structures A and B from the mark scheme and were able to select the correct isomer; however, the explanations of the nmr spectrum were rarely precise enough to merit the final mark. Many candidates understood why P is a solid at room temperature; the common incorrect answers suggested hydrogen bonding or made vague reference to strong intermolecular forces. A few candidates misinterpreted the question and stated that P is a solid at room temperature because it has a high melting temperature.

Question 24

Most candidates suggested a suitable reagent to generate the electrophile for the electrophilic substitution of methylbenzene. Some candidates used the obsolete name, methyl chloride, here; while this was not penalised, it should be discouraged. The mechanism for the electrophilic substitution of benzene is a frequently asked question so, unsurprisingly, candidates at all levels scored quite well on 24(a)(ii) & (iii). The most common difficulty was in drawing the intermediate where the presence of the methyl group in the reactant required candidates to understand precisely the placement of the horseshoe in the Wheland diagram; other common errors at this point were the use of dotted bonds to attach the incoming methyl group and the hydrogen atom, and the appearance of a positive charge on the hydrogen atom. Elsewhere, the most likely source of error was in the placement of the curly arrows, particularly in the reforming of the benzene ring structure when the arrows frequently originated from the hydrogen atom and terminated outside the ring.

There were many textbook answers to 24(a)(iv) and, even when the role of the methyl group was poorly understood, the second mark proved accessible. Most candidates appreciated the need for a strong acid in 24(a)(v).

In 24(b)(i) the significance of variable oxidation numbers in catalysis was widely appreciated, many candidates ignored the cue in the question and discussed features of heterogeneous catalysts and some just listed the properties of transition elements.

The responses to 24(b)(ii) showed little evidence of application of basic chemical ideas. The most common answer was that the active sites became saturated with reactant molecules while many candidates discussed the system in terms of enzyme chemistry, suggesting that the vanadium(V) oxide was denatured.

For the most part, 24(c)(i) was only accessible to the best candidates, with most unable to apply their knowledge of esters in an unfamiliar context. A wide range of incorrect answers appeared, the most common involving substituting the two methyl groups onto the benzene ring.

Few candidates appreciating the structuring of 24(c) which was intended first to remind candidates that there were two different covalent molecules involved in a typical plastic: the polymer and the plasticiser, second to lead candidates to think in terms of the intermolecular forces present and third to apply these ideas in a novel context. In 24(c)(ii) only the better candidates realised that the interactions involved were familiar intermolecular forces and subsequently in 24(c)(iii) that the flexibility of the plastic depended on the interactions between the two different molecules present. This most answers to 24(c)(ii) were based on the idea that the water in drinks would lead to the breakdown of the polymer by hydrolysis while many responses to 24(c)(iii) simply reiterated statements from the introductory passage.

Question 24(d)(i) & (ii) were more familiar and elicited many correct responses although the use of hydrogen chloride for the preparation of an acid chloride was quite common. The best candidates scored well on the structure of terylene but weaker candidates often appeared to have no idea where to start. Some responses involved no ester groups at all, suggesting that these had not read the passage through, but many candidates who did realise that a polyester structure was required were unable to complete the structure with anything like enough precision. Again only the best candidates realised that methanol would be the by-product of the ester exchange, the overwhelming majority of candidates suggested that water would be formed.

Advice to candidates

Remember that at this level you are expected to apply your knowledge and understanding in unfamiliar situations.

Learn how to plan calculations so that the intended outcome is clearly understood from the start.

A surprising number of examination marks are lost through entirely avoidable errors, particularly through failure to carry out the instructions in the question correctly or fully.

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