



Examiners' Report Principal Examiner Feedback

January 2021

Pearson Edexcel International Advanced
Subsidiary / Advanced Level
In Chemistry (WCH12)
Paper 1 Energetics, Group Chemistry,
Halogenoalkanes and Alcohols

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Introduction

Some students were well prepared for this examination and were able to demonstrate that they had a good knowledge of the topics in the specification. For instance, sound knowledge of intermolecular forces was demonstrated by many, both in Section A and Section B and many students could apply IUPAC rules to halogenoalkanes. Simple quantitative problems were accessible to all, however the unstructured nature of some calculations proved very challenging for some of this cohort. Assessment of familiar ideas set in new contexts, such as enthalpy changes, added a level of demand that for some was exacting.

Section A

For some students, this section was the most mark-yielding section of their paper. Questions 2 and 3, on intermolecular forces, were answered correctly by many as was question 13 (deducing an organic structure from its name) and question 16 (calculating the amount in moles from the volume of a pure liquid).

The most challenging questions were Q6(b) (calculating a change in oxidation number), Q14(b) (deducing the number of alkenes formed in a dehydration reaction) and Q18 (reacting volumes and concentration ratios).

Question 19

The best responses to part (a) had a systematic approach to structuring the answer, using the stem of the question to help frame their explanation. Such students worked through each of the features of the reaction, attempting to explain how these affected the reaction. Hence these solutions were far less likely to omit to discuss a key feature. Indicative points 3 and 5, in relation to the position of the equilibrium, were most commonly seen, though a minority of students believed that an increase in temperature would increase the yield 'because it increases the rate'. Some students appreciated the word 'compromise' was important but simply stated this as a fact without any clear inference to the reaction conditions. Only the best answers appreciated the low yield was acceptable as reactants could be recycled. Those that did consider the low yield often attempted to justify it by the fact that industry makes ethanol in bulk using huge amounts of reactants, so a 5% yield would still result in a lot of ethanol being formed.

A small but noticeable number of students didn't consider rate or equilibrium and based their answer on the assumption that huge amounts of energy was needed to break the carbon-carbon double bond.

In part (b), most students realised hydrogen bonding was the key principle involved. However, diagrams showing an understanding of how the bond formed in this case proved more

problematic. Missing or incorrect dipoles were quite common. It is important to check the structure of even simple molecules such as water, to avoid unforced errors.

A useful strategy when justifying solubility is to consider the forces evident in the solvent and in the solute, and then compare these forces to the resultant solute-solvent forces. A small number of answers used this strategy effectively.

Approximately half of the cohort could correctly deduce and draw the structure of Y (ethanal) in (c)(i) and a small number attempted to draw potassium dichromate(VII).

It's worth noting that if two structures are given by the student for this sort of question (eg skeletal and displayed), they both need to be correct.

In (c)(ii) most candidates understood that the use of distillation or heating under reflux was the key to obtaining each product. However, a minority of students seemed unfamiliar with the reaction and suggested generic conditions such as 'pressure' or 'temperature'. Use of high pressure made it difficult to award the use of reflux for ethanoic acid.

Question 20

In (a)(i) the structure of compound A was deliberately drawn with the longest carbon chain not shown horizontally across the page. As a result, the question did discriminate effectively, with the majority of answers based on a 5-carbon chain. In general, those that realised the longest chain was 6 carbons tended to go on to name the compound correctly. Nearly half of the cohort suggested a suitable chlorinating agent in (a)(ii), with PCl_5 by far the most common correct answer. Conversely by far the most common 'near-miss' was the answer 'HCl' without any reference that it would need to be concentrated to work effectively.

In (a)(iii), the best mechanisms seem to use a combination of both recall of detail and understanding of the process to score full marks. Other students clearly had some understanding of the key features of the process, but tried to work through the question using a simpler model of nucleophilic substitution, perhaps using their recall of the reaction with a hydroxide ion. Hence it was relatively common to see NH_3^- or NH_2^- as the attacking species in the first step. Others correctly identified the intermediate, and the need to lose a hydrogen ion, but moved the bond pair of electrons onto the hydrogen.

In (b)(i) the application of a key idea was assessed, and this allowed a significant degree of differentiation. Many students appreciated that the lone pair of the nitrogen was critical but then based their answer in terms of hydrogen bonding formation. However some students who answered on general terms about a lone pair on the amine group / ammonia and without

further discussion did not score. Others discussed ionic bonding alkylammonium ion and the chloride ion, highlighting that reading the question with care is always important. It was pleasing to see a number of students appreciate that the hydrogen ion possessed a vacant orbital, to allow the dative covalent bond to form.

In (b)(ii) it was evident that application again challenged some students as the ion-dipole model was not always recognised as relevant. Some attempted to draw covalent electron density maps, and others showed interaction with hydrogen ions and chloride ions rather than water. Of those students who focussed on the interaction with water molecules, omissions and errors with the dipoles on water were quite common, as were models based on a single water molecule interacting with both ions. The best answers showed at least two correctly orientated water molecules interacting with each ion.

Question 21

In (a), the realisation that bubbles would be seen was almost universal. The second mark was harder to come by though, with lots of students opting for generic answers such as the formation of a precipitate or a colour change of solution. A noticeable number of students described 'sodium' as dissolving, so did not score the second mark. Care should be taken when transcribing information from the stem of the question.

The unstructured nature and novel context of (b) was a significant challenge for many of this cohort. The use of $\Delta_r H$ to determine the amount of energy released by the hand warmer eluded many. Others realised this step was important but could not calculate the relative formula mass of hydrated sodium ethanoate, omitting the mass of the water molecules. It was equally common to see 63.2 used as the mass of the hydrated sodium ethanoate when determining the amount. The conversion of kJ to J was left out by some, leading to a negligible change in temperature. There was little evidence of evaluation of a final value in light of the context of a hand warmer. Hence such tiny changes, temperature decreases and extremely high final temperatures were just accepted by students. Several solutions presented the answer as a single algebraic expression.

Whilst laudable in many respects, errors such as those previously mentioned were still prevalent, suggesting that whilst these answers were mathematically competent, the appreciation of the chemistry still needs development.

In (c) just a few candidates could write a balanced equation for the reaction of ethanoic acid with ammonium carbonate. For many, this then limited their ability to tackle the subsequent calculation and it is clear that the skill of putting together a Hess Cycle for a reaction, based on

enthalpy changes of formation, needs practice. In general, those who could write the equation for the reaction went on to correctly calculate the enthalpy change of the reaction.

Part (d) was accessible for most students. The few mistakes that were seen involved errors in finding the relative formula mass of ammonium carbonate. Most students calculated the moles of ammonium carbonate, then used the equation concentration = moles \div volume, rather than scaling up by a factor of 10. This meant a few students did not convert the volume to dm³ so did not score the second mark.

Question 22

The ability to combine equations to find an overall equation in (a)(i) proved a useful discriminator and it is a skill that would be beneficial for many students to practice. Unfortunately, some students didn't attempt this part, making it difficult to get significant credit in (a)(ii). However, many of those who did give an answer to (a)(i) were able to go on and show some evidence that they understood the principles behind atom economy, by scoring marks based on transferred errors. In (b) most students recognised the reaction as disproportionation and although a proportion of these were able to link the oxidation and reduction of chlorine to appropriate changes in oxidation numbers a sizeable minority tried to justify their answer in terms of changes in oxidation number for calcium or hydrogen.

Part (c)(i) allowed many students to show their understanding of the qualitative test for halide ions, with the third mark for the use of dilute ammonia solution proving to be a useful discriminator. A small number seemed to confuse the test which the formation of Tollens' Reagent and so added sodium hydroxide alongside the silver nitrate. This then put the second mark at risk as it would lead to a precipitate of silver hydroxide.

The calculation in (c)(ii) was demanding for many students. A few made the link between the change in mass and the loss of oxygen and based subsequent calculations of amounts on either 1.52 g or 1.02 g, which were invalid as these masses contained the impurity. Although a relatively novel context, this question had parallels with similar experiments to find the number of moles of waters of crystallisation in a hydrated salt. In both cases the loss of mass can be linked to an amount in moles as a starting point. Only a small number of students made this link, though some students solved the problem algebraically by letting x = the mass of the impurity and then finding x .

Despite the fact that the naming system for chlorates was modelled in the stem of part (d), less than a third of candidates correctly identify potassium chlorate(VII). In most cases this was due to a failure to correctly work out the oxidation of chlorine, but in other attempts the

use of oxidation numbers was ignored with names such as potassium tetraoxochloride suggested. The systematic use of oxidation numbers in names needs to be practised.

In part (d)(ii) the ability of candidates to understand how experimental work could be used to show a particular feature of catalysts was tested. The quality of answers varied significantly. As in Q19(b), the best answers adopted a systematic approach, working through each step to try to justify its inclusion in the procedure. However, some did little more than copy out text from the question. Others spent unnecessary time explaining how catalysts work, which was not a requirement of the task. The most common mark achieved was the realisation that Step 5 enabled a comparison of the initial and final mass. Some answers missed credit because their explanations lack key details. For instances many referred to Step 3 in generic terms, discussing the 'removal of impurities', but to score credit the best answers made it clear that either KCl or KClO_3 or 'soluble impurities' were being removed. It is always best, if possible, for students to frame their answers in the specific context of a question.

Part (e) was competently handled by many, though a proportion of students, despite the instruction from the question, did not use the diagram at all to illustrate their answer.

Summary

In order to improve their performance, students should:

- use the stem of the question to help structure answers to extended response questions. These questions can often be broken down into two or three smaller, less daunting problems.
- practice justifying solubility by considering relative strength of solvent-solvent and solute-solute forces against the resultant solvent-solute forces.
- when naming organic compounds from structures don't assume the longest chain runs horizontally across the page.
- use look, cover, write, check as a starting point when learning mechanisms. This will embed the key stages of each reaction and enhance your understanding. You will then be in a stronger position to apply these ideas to less familiar reactions.
- always read questions carefully, especially if the context is unfamiliar. This will help you improve your ability to pick out suitable chemical ideas to apply.
- practice as wide a range of chemical calculations as possible. Write a commentary on your working, outlining how you solved the problem. This will help embed ideas and give you a model to call on when you face novel problems.
- practice drawing a range of Hess Cycles.
- look at numerical answers in the context of a question and ask yourself 'does that value look realistic?' If not and time permits, review your answer, as you may be able to spot a simple to rectify error.

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