Examiners' Report
Principal Examiner Feedback

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Pearson Edexcel International Advanced Level
In Chemistry (WCH14)
Paper 01: Rates, Equilibria and Further Organic Chemistry

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Introduction

This paper provided a full range of marks. Some candidates scored were clearly very well prepared and scored very high marks. Questions directly related to the content of the specification points, demonstrated by explanations and descriptions, clearly showed that many candidates had acquired this knowledge. Calculations were generally well answered with a number of candidates providing excellently laid out answers which were easy to mark. Items requiring application of this knowledge were less successfully answered, particularly in Section C. 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.

Section A

The mean mark for the multiple choice questions was 12.

The questions the candidates found easiest were 1(b), 12 and 13 with 4 in every 5 candidates on average scoring these marks.
10(c) was the most difficult of the questions, with only 1 in 3 candidates scoring this mark. 3(b), 5(b) and 10(c) were the also difficult, with less than half the candidates scoring these.

Section B

Question 14

(a)(i) proved somewhat harder than some questions naming organic compounds. Nitriles are often found difficult to name, with ethanenitriles a quite often seen incorrect answer. Fewer than 50% of candidates got the answer to this item correct.

(a)(ii) was generally well answered by many candidates. Some completely correct answer were seen (about 20%). The most common marks were 0 and 3, indicative of candidates who did not know where to begin with this mechanism and of candidates who had a really good idea, but made perhaps one small mistake. Just under 50% score either 3 or 4 marks so this question was answered very effectively.

(a)(iii) proved very challenging. Quite a few candidates could did not seem to know what nucleophilic addition meant, and some who clearly did struggled to apply it to this example. Many candidates could not describe ‘addition’, often saying the HCN or nitrile ion ‘added’ to the ethanal. The command word, justify, requires some evidence to support the conclusion, so the answer required a comment about nothing being lost or substituted, or there only being one product. In general if asked to explain a term like ‘nucleophilic addition’ or, for example, ‘thermal decomposition’ alternative words or phrases need to be found for this. So nucleohile, add, thermal or decompose would be unlikely to score marks.

The last item in this question, 14(b), the idea of the formation of a racemic mixture, was much better understood by candidates. This is quite a familiar question, and those who did not score one or both of the marks, clearly had a good idea about the topic, but could not express themselves with sufficient clarity.

Question 15

As in the previous question the first item, (a)(i) and (a)(ii), proved quite challenging. Some excellent answers were seen that were clearly laid out and it was easy to award marks. The use of ICE (initial, change, equilibrium) 'tables' in (a)(i) was seen commonly by markers, and candidates using these were quite easy to follow through their calculations. Very few candidates were not able to score something on these two items. All the range of marks from 0 to 7 were scored at an approximately equal percentage, so this was a very discriminating question.

In (a)(i) there were two very common mistakes. One was to use the relative atomic mass of O, or perhaps twice its atomic number, instead of the relative molecular mass of oxygen molecules to find the number of moles of oxygen at equilibrium. Consequently 7/16 was seen often instead of 7/32. I would estimate this was about a third of the candidates, a surprisingly large number. The second mistake was to assume, perhaps a little more understandably, that the number of moles of NO and of NO_2 were the same, since they have the same stochiometry in the equation. This was not the case, however, as one is a product and one a reactant. The stochiometry was needed instead to find the number of moles of NO, which was twice the number of moles of O_2. There were quite a range of values for the moles at equilibrium seen in (a)(i) but all could be carried forward to (a)(ii).

(a)(ii) seemed to be more straightforward for many candidates than (a)(i). All values from (a)(i) could be carried forward through the calculation in (a)(ii). The four steps in (a)(ii) were to find the concentrations, by dividing by volume (15), make use of the expression for K_c, substitute the values for concentration into the expression and give the final answer including units. The first step was often not done, and calculation using the moles of substance in the expression for concentrations was done instead. This still allowed three marks to be scored out of the 4 and this happened quite commonly. There were fewer mistakes in the next two steps, though some candidates used an expression for K_c which was upside down, and some candidates forgot to square their concentrations for NO and NO_2 (or both) even though they had quoted the squared term in their expressions. The final answer from the calculations, allowing for any errors in earlier steps, was often correct and the units were also well identified, so the final mark was quite often scored.

(b) was a calculation involving the use of $pV = nRT$. Candidates had clearly practised these types of calculation and about 40% scored all the marks, with a further 30% scoring 2 out of the three available. The commonest mistakes were to not convert the volume to cubic metres or to use an incorrect number of moles of gas.

The next item proved surprisingly difficult, with only one third of candidates getting the correct answer. The most common mistake was to suggest that NO was brown and NO_2 was colourless. Since the candidates should be award that NO_2 is the brown gas produced on thermal decomposition of a Group 2 nitrate, this was a surprise. Another common error was to simply say that there must be a change in colour. This is, of course, true for colorimetry to be used, but but the question was about this particular reaction so this knowledge needed to be applied.

(c)(ii) scored very well, with three quarters of candidates getting at least one mark and nearly half scoring two, but (iii) proved much more difficult. Some candidates understood it was to do with the number of particles but they did not clearly say that a simultaneous collision of three particles was unlikely. Some very well prepared candidates mentioned not only the chance of collision but also the orientation of the molecules as well.

In (c)(iv) many candidates had a good idea of the answers, but the command word 'Justify' again caused them problems. Some also did not see the bold **and** in the question so only considered the overall equation or the rate equation but not both. There were a number of excellent answers saying that the overall equation was consistent, with no justification and a very full description of why the rate was not consistent, and vice versa. 14% of candidates were able to justify both.

Question 16

The first item was (a)(i) to (a)(iii) which were considered together. (a)(i) and (a)(ii) were separate calculations which candidates were often able to get correct. Occasionally the calculations were correct but for the wrong item. This still gained credit but not the full six marks. (a)(iii) scored well, with 2 or 3 marks quite common, with small mistakes, usually the omission of one of the equations or a statement that the reactions were feasible losing one of the marks. Again this set of items scored quite well, with 8 marks out of 9 being the most common score, with over 60% of candidates scoring at least 6 marks.

The calculation in (b)(i) was well done by the 45% of candidates who scored at least 3 marks, with the most common error being the failure to match the units by converting one of the two values by multiplying or dividing by 1000.

In (b)(ii) many candidates recognised it was the temperature that was important by often the cost was considered to be the issue, rather than the fact that it was too high to get to that temperature.

Question 17

Part (a) was the extended writing question. This was accessible for many candidates, but a surprising number did not score any marks. Scores of 1 to 4 were common with only about 5% getting either 5 marks or 6. Many candidates did not read the question with sufficient care and quoted large numbers of tests, many with more than one positive result, which were not allowed by the question. This affected the reasoning component of the marks.
(b) focussed on NMR spectroscopy, and this was very well understood by a good number of candidates. 40% scored the mark in (b)(i) with the most common error to focus on the commonality of the C=O bond, which was true, but did not answer the question rather than the number of carbon environments which did. (b)(ii) scored well, with over 40% scoring all three marks. This was the most common score. Nearly 60% scored the mark in (b)(iii) with many more probably knowing the answer, but drawing a structure of butanoic acid without indicating which was the hydrogen responsible for the peak. It is worth noting that the OH hydrogen on a skeletal structure must be drawn and none of the others must be, so if this was given as the answer we could not accept that the candidate knew it was this hydrogen responsible without further indication.

(b)(iv) was a little more challenging and only 35% of candidates scored 2 marks. If the candidate recognised the structure responsible and the reason they rarely only scored 1 mark (10%).

Section C

Question 18

This question presented a series of items based on acid-base equilibria in the context of a titration sketch graph. Many candidates were able to apply their knowledge to these items, but many also found the application of their knowledge in this context much more challenging. Candidates must be able to apply their knowledge to unfamiliar contexts and this question tested this skill fully.

(a)(i) was the calculation of the pH of a weak acid of known concentration. Over 50% of candidates scored full marks, but about 35% scored 0. Scores of 1 mark or 2 were very rare. Those candidates who applied their knowledge to the context did so with great skill and were well rewarded.

In (a)(ii) over 30% of candidates were able to deduce that the pH of the potassium hydroxide solution was 13 before adding to the acid, scoring 1 of the 2 marks. Some then went on to say that this was the maximum pH, but did not explain why, so gained no further credit. Some candidates then justified the value being less than 13 by describing dilution by the acid solution or the neutralisation of some of the hydroxide ion to score the second mark which was the original intention of the question. Some did this by calculating the effect of the dilution by calculating the pH of a solution of potassium hydroxide which had been diluted by 30cm^3 of water (12.8), although this was not required. Others calculated the actual pH of the solution (12.4) though this was specifically not required by the question. This complex calculation was awarded full marks if carried out successfully.

(a)(iii) was a number of moles calculation finding the neutralisation point. About a third of candidates scored both marks. This is a relatively straightforward skill, so some of the candidates not scoring were perhaps put off by the context.

(a)(iv) was answered correctly by about 40% of candidates.

In (a)(v) those who recognised that the key point was the half neutralisation point usually scored two marks. Some scored only one mark, usually by attempting a calculation other than the straightforward pH = pK_a calculation. Full buffer calculations were often seen, with many being fully correct (getting 4.86 as the value of pH). Those that were incorrect were able to score 1 mark for finding either two equal concentration or two equal number of moles for the acid and the pentanoate ion.

The buffering region in (b) was recognised by a good number of candidates, scoring 1 of the marks. Justification of its role as a buffer was rather more difficult, with over 50% scoring at least 1 mark but only 7% scoring 3. Errors included not mentioning the reservoir of pentanoic acid (the reservior of pentanoate ions, though sometimes mentioned, was not required by the question) or not giving enough detail about how the solution reacted with the added hydroxide ion.

The description in (c)(i) tested not only the candidates ability to recognise the colours of methyl orange indicator at different pH, but also how those colours would change during the titration. Consequently a number of candidates scored 2 marks by correctly deducing the colours at particular key points (as suggested by the question) or particular pHs (as suggested by the information in the Data Booklet). There needed to be an accurate description of the gradual change in colour of the indicator, and therefore that it was inappropriate for the titration, to gain the final mark. Many candidates did not read the question with sufficient care and answered the more usual questions which are 'Explain which indicator is more appropriate for this titration' or 'Justify whether or not methyl orange is a suitable indicator for this titration'. The latter did at least give some opportunity for scoring some marks. The former lead to answers usually quoting phenol red or phenolphthalein. These showed excellent chemical knowledge but did not answer the question so could not score.

The final item was also unusual in context and again phenol red featured prominently as an incorrect answer. Perhaps for a similar reason, that candidates were looking for an indicator with its pK_{in} in an appropriate region which was yellow in acid solution, but then ignoring the green colour at neutralisation. Phenol red would, of course, be orange at the end-point of the titration. Phenol red could gain no credit, but bromocresol green or bromophenol blue gained credit for the idea that the colour at neutralisation would be green. We also allowed this mark for bromocresol blue, a hydrid of these two names, which, although not given in the Data Booklet, is an accepted alternative name for bromocresol green.

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 knowledg and understanding
- Layout calculations clearly, labelling what each calculation is attempting to achieve. This helps to clarify their 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.
- Practise the naming of organic nitrile compounds, which are one of the more difficult groups to master.
- Continue to practise basic calculation skills using n = cV and n = m/M and finding the molecular mass of molecules, including such simple ones as O_2, which is still being tested, usually early on in a calculation or series of calculations.
- Practise the drawing mechanisms, remembering to include dipoles and lone pairs of electrons when relevant. Remember that arrows start either from a lone pair or from a bond, not from empty space and go to an atom (or ion) rather than a long way from them.