Examiners' Report
Principal Examiner Feedback

January 2023

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

General Comment

This paper was similar in style and standard to previous Unit 4 papers of this specification; a range of skills and knowledge was assessed and the levels of difficulty allowed good discrimination between the different grades, while allowing well-prepared candidates at all levels to demonstrate their abilities. This is an A Level examination paper and therefore had a synoptic element but, for the most part, candidates seemed better prepared for the standard questions rather than those requiring application of knowledge and understanding in unfamiliar contexts. Candidates often lost marks because they did not answer the question that was actually set or seemed to ignore information and clues given in the stem of the question.

Multiple Choice Section (Questions 1-16)

This was the highest scoring section of the paper with a mean score across all candidates of 61.4%. 90% of candidates gave the correct answer to question 16 and 88% of candidates gave the correct answer to question 2 , while just 17% of candidates gave the correct answer to question 1(a), the lowest scoring question.

Question 17

Although the investigation of an iodine clock reaction is a core practical for this unit, most candidates appeared unfamiliar with its principles. Many responses to 17(a)(i) attempted a description of a titrimetric method, often with thiosulfate as a reactant. Candidates were most likely to score the mark for the colour of the starch-iodine complex although some thought that starch reacted with iodide ions. In (a)(ii) the vast majority of candidates were able to give the correct format of the rate equation but deducing the orders of reaction seemed much more of a challenge. However, many were able to get two of the orders correct with a reasonable number scoring full marks. The marks for calculating the rate constant from their rate equation was accessed by most candidates with a high proportion able to deduce the appropriate units.

There were some excellent answers to (b) with the method clearly set out and accurate working. As well as the purely algebraic solutions, some candidates treated the data as points on a graph and determined the gradient. Rather too many candidates attempted to solve the equation by substituting the values at one temperature and ignoring the constant. Candidates at all levels gave incorrect units or inappropriate numbers of significant figures.

Question 18

Part (a) produced a wide range of responses with some excellent accounts of the optical isomerism of lactic acid from different sources although very few candidates scored IP6. A number of candidates seemed to have little understanding of optical isomerism but the main issue was in the structuring of their answers which led to the inclusion of material that was inappropriate to the specific question and resulted in the loss of marks. The most obvious example of this was to confuse nucleophilic addition and nucleophilic substitution; this led to references to S_N1 and S_N2 mechanisms and planar carbocation intermediates. Candidates often gave loose and inaccurate

terminology to describe the effect of optical isomers on the plane of plane-polarised light: reflect, deflect and bend were often used in place of rotate. (b)(i) produced a range of responses; a high proportion gained the ester linkage mark with a good number going on to complete a fully correct structure or a near miss with the omission of an oxygen atom being a common error. Despite the indication in the stem of the question that poly(lactic acid) was a polyester, candidates gave a variety of links, including ether, ketone and carbon chain. A number of structures included trivalent or pentavalent carbon atoms. It was rare to see an incorrect molecular formula in (b)(ii) but candidates often failed to link the formula to the subsequent spectra. In (b)(iii) the point that the number of peaks corresponded to the number of proton environments was not always made and the use of the term 'chemical environment' occurred quite frequently. Despite having a correct molecular formula, many candidates stated that there were three protons in one environment and one in the other. The explanations of the splitting patterns were generally good; candidates need to be aware that in this type of question, an analysis of the splitting pattern should be specific to the molecule under consideration and that general accounts of the 'n+1' rule will not score. The most common way to score a mark in (b)(iv) was by identifying the ester peak although many candidates also recognised that there were three carbon environments; there were few references to the number of carbon atoms in each environment. There was little evidence of candidates linking the different parts of 18(b) to deduce the structure of the lactide X. The few that drew the correct structure appeared to use trial and error rather than the evidence from the NMR spectra and the structure of poly(lactic acid).

Question 19

About 75% of candidates were able to score the conditions mark in 19(a), most of the remaining candidates seemed quite unfamiliar with the use of lithium tetrahydridoaluminate(III). There were many fully correct mechanisms drawn for 19(b) and also many with only one or two errors. Some candidates lost marks due to their incorrect placing of the curly arrows, while the failure to appreciate that the hydride ion had a lone pair was another common problem. A number of candidates gave the second step as a reaction between the intermediate and another hydride ion, despite the clear statement at the start of the question that this stage involved reaction with a strong acid. Candidates seemed to find it hard to express their ideas clearly in 19(c). There were many references to electron clouds and π bonds but even when bond polarity was mentioned it was often unclear which bonds were being referred to. Some did make the link between bond polarity and mechanism.

Question 20

The sequence of calculations in 20(a) was completed correctly by a good number of candidates. The majority used correct units throughout and showed these clearly. Some candidates used entropy units of J K^{-1} mol^{-1} in (a)(i) and kJ K^{-1} mol^{-1} (a)(iii) which could lead to difficulties in (a)(iii). Errors were far more common in (a)(ii) than in (a)(i) due to the data in the former having positive and negative values. In (a)(iii) the negative sign in the $\Delta S_{surroundings}$ expression was likely to be omitted, especially if the enthalpy change obtained in (a)(ii) was exothermic. This also could cause problems in (a)(v) if candidates simply eliminated the negative sign at the end of their calculation. The equilibrium constant expression in 20(b)(i) was usually correct, the most likely errors being the use of square brackets or the omission of the partial pressure symbol. There were many fully correct calculations in (b)(ii) complete with appropriate units. Candidates were most likely to go astray when calculating the moles of the components at equilibrium, often having different amounts of ethane and ethane. However, the remaining marks were available with the clear presentation of the method facilitating the awarding of these. Here, and also in the calculations in question 21, some candidates rounded their intermediate values; correct intermediate rounding is not penalised but it is not good practice.

Question 21

Although there were some round brackets in the K_a expression for 21(a)(i) the most common error was to write the chemical equation for the dissociation. The calculation in (a)(ii) was very frequently correct; common errors included failing to convert the concentration of the gluconic acid into mol dm^{-3} and omission of the square root to obtain the concentration of hydrogen ions. In (b)(i) Candidates almost invariably gave the correct range for phenolphthalein. However, the explanations often did not relate this to the vertical section of the titration curve, instead referring to 'the equivalence point'. The number of candidates who worked their way through the calculation in (b)(ii) showing a clear, logical method was impressive. For those who understood the basic strategy required to solve this problem, the scaling step was most likely to be omitted. Some errors led to an acidic final pH but candidates who got to this point rarely reviewed their calculation. There were many excellent descriptions of the operation of a buffer solution for (c)(i). However, some candidates progressed no further than writing the equations for the addition of acid or alkali without explanation and others simply gave the standard definition of a buffer solution. In (c)(ii) candidates who relied on the Henderson-Hasselbalch equation often ended up with an incorrect sign, or the [acid] and [salt] inverted. Those who worked from the K_a expression were much more likely to score full marks.

Paper Summary

Based on their performance on this paper, candidates should:

- be aware that in this examination they will be tested, in part, on their ability to apply scientific knowledge and processes to unfamiliar situations
- remember to read questions carefully, be familiar with the meanings of command words and be alert for information that might be helpful in formulating their responses
- ensure that they are answering the question that is being asked, and answering it in full, avoiding giving superflous information that is related to the topic being tested but irrelevant tothe question
- make sure that they understand the exact significance of curly arrows in organic mechanisms and the placement in terms of their origin and destination
- practise setting out their calculations in a clear and logical way so that they can check each step
- practise keeping intermediate calculation values in their calculator and only rounding the final value
- practise considering whether the values they obtain from their calculations are chemically realistic and are consistent with other information in the question.