



Examiners' Report

Principal Examiner Feedback

October 2021

Pearson Edexcel International Advanced Level

In Chemistry (WCH14) Paper 01

Rates, Equilibria and Further Organic Chemistry

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## **Introduction**

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 students at all levels to demonstrate their abilities. This is an A2 examination paper and therefore had a synoptic element but, for the most part, students seemed better prepared for the standard questions rather than those requiring application of knowledge and understanding. Many students lost marks because they did not answer the question that was set. The quality of the graphical work seemed better than in recent series, particularly in the choice of scales and the accuracy of labelling axes. There was definite scope for improvement in the use of units.

## **Section A (Multiple Choice)**

This was the highest scoring section of the paper with a mean score across all candidates of 62.8%. Question 4 was most accessible with 80% of candidates giving the correct answer; question 9 proved the most difficult with 40% of candidates giving the correct answer.

## **Question 16**

In (a)(i) many candidates failed to appreciate that the presence of water in the oxygen would impact the measurement of the water formed in combustion and suggested instead variations on the idea that water would affect the chemical reactions occurring.

The calculation in (a)(ii) is of a type that has been set previously but many candidates seemed unfamiliar with the approach based on calculating the mass of oxygen in the compound. Candidates frequently calculated the moles of carbon and hydrogen correctly but were unable to progress. There were very few responses based on the inductive method using the balanced equation.

The tests in (b)(i) were well known and there were some excellent responses. Candidates often lost marks by failing to link each piece of information to the presence or absence of a structural feature, for example just stating that the results of the tests with Brady's reagent and Tollens' reagent showed a ketone was present; without a more detailed explanation this gained just one mark. The carbon-13 NMR information was quite frequently ignored or just linked to the presence of four carbon atoms.

Candidates who correctly identified the two possible structures in their answer to (b)(i) were very likely to score two or three marks in (b)(ii) with a slightly incorrect reagent being the most common error.

While there were some excellent answers to (c), many candidates seemed unfamiliar with the basics of proton NMR and problems were compounded when candidates did not structure their answers. There were several common errors: failure to link the peak heights with the numbers of proton environments; associating chemical shifts with functional groups rather than the neighbouring protons; giving general rather than specific explanations of the absence of splitting.

### Question 17

The graph in (a)(i) was usually drawn well with a good choice of correctly labelled scales and accurate plotting of the points.

For (a)(ii) most candidates determined a half-life within the accepted range, with the vast majority showing their working on the graph as required.

The calculation of the rate constant in (a)(iii) was completed successfully by most candidates, the most common errors were quoting incorrect or no units.

The calculation of  $\ln k$  and  $1/T$  in (b)(i) were usually completed competently as was plotting of the point in (b)(ii); some candidates did not write their value for  $1/T$  but were allowed the mark if the point was plotted correctly.

The best fit line required in (b)(iii) was usually drawn correctly and most candidates were able to determine the gradient, the common errors were the omission of one of the negative signs or the inversion of the gradient expression. However, many candidates were unable to supply the correct units for the gradient.

The calculation of the activation energy in (b)(iv) was generally completed successfully although units were often a problem here also.

### Question 18

Most candidates knew that the hydrolysis of primary halogenoalkanes proceeded via an  $S_N2$  mechanism while for tertiary halogenoalkanes  $S_N1$  was favoured. Some candidates wrote the rate equations for the two types of reaction but relatively few candidates correctly identified the rate determining steps of these reactions and gave the relevant intermediate or transition state. While there many well-constructed answers, some candidates devoted space to re-stating information given in the question and detailed descriptions of the role of the different mechanisms in the formation of pure optical isomers and racemic mixtures were very common.

### Question 19

The expression for the pressure equilibrium constant for (a) was given by most candidates although square brackets did appear, and some answers omitted an indication of partial pressure.

Most candidates were familiar with the calculation required in (b) and there were many fully correct answers. Common errors were failure to calculate the moles at equilibrium, so that a total of 2.45 mol was used, and the omission of or incorrect units. Many candidates gained the first two marks in (b) although some omitted one or both explanations and others confused the increase and decrease in yield effected by the change in conditions.

The final mark was awarded relatively rarely and usually for stating the need for the temperature to be set to produce a reasonable yield at a practical rate. Very few candidates appreciated that the data indicated that the equilibrium yield would be far lower than 95% and this could only be achieved by recycling unused reactants.

### Question 20

Writing the equation for the dissociation of the hydrogensulfate ion in (a)(i) proved a significant challenge for many candidates. While most candidates appreciated that the formation of a hydrogen or oxonium ion and a sulfate ion was involved, a significant number of these gave the sulfate ion with a single negative charge.

Other candidates wrote or attempted to write irrelevant equations, including the dissociation of sodium hydrogensulfate or sulfuric acid or reactions involving the formation of the hydroxide ion. Most candidates seemed familiar with the type of calculation required in (a)(ii) but only a minority were able to complete it successfully.

The most common errors were in the conversion of the concentration from  $\text{mol dm}^{-3}$  to  $\text{g dm}^{-3}$ : some omitted this step altogether, giving their answer in  $\text{mol dm}^{-3}$  as  $\text{g dm}^{-3}$ , others calculated the molar mass of the hydrogensulfate ion rather than that of sodium hydrogensulfate. Candidates who relied on a memorised formula such as  $[\text{H}^+] = \sqrt{K_a \times [\text{HSO}_4^-]}$  rather than working from the  $K_a$  expression frequently became confused about what they were calculating.

Although the assumptions that underpin the standard calculations from the  $K_a$  expression have been examined on several occasions, candidates are still prone to two simple errors: using generalised statements when what is required is the application of these principles to the specific case; giving two versions of the same assumption. While the definition of a buffer was well known, candidates still omit the important restriction that 'small' amounts of acid or alkali are added and stating that the pH of a buffer does not change at all.

A few candidates tried to guess the meaning of the term from the background statement about the use of the hydrogensulfate-sulfate buffer given in the stem of the item. Candidates were generally familiar with the calculation of the pH of a buffer, and many completed the calculation successfully. Those candidates who relied on memorising the Henderson-Hasselbalch equation, rather than working from the  $K_a$  expression, were once again less likely to reach the correct answer.

In (b)(iii) those who attempted the calculation of the pH when hydrochloric acid was usually successful, but this part was quite frequently omitted altogether, even by candidates who completed the buffer calculation. The method of calculating the effect of adding acid to a buffer solution was not widely understood. Candidates who appreciated the correct approach often calculated the new concentration of the sulfate or the hydrogensulfate ions rather than both. Another common error was the inversion of the concentrations in the Henderson-Hasselbalch equation. Candidates who miscalculated rarely seemed to appreciate the significance of an increased pH.

The three marking points required for (c) rarely appeared in a single answer. The mark most likely to be scored was that the colour change of methyl orange would be complete well before the equivalence point, but this was often combined with irrelevant material. Many candidates failed to address the actual question, instead explaining why methyl orange was an unsuitable indicator for this titration.

## **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
- know how to choose the appropriate number of significant figures to use in giving the final answer in a calculation
- remember only to round the final answer to a calculation
- understand how to derive the appropriate units for a calculated quantity
- make sure that they are familiar with the method for calculating the formula of an organic compound from combustion data
- practise the method for calculating the change in the pH of a buffer solution on the addition of small amounts of acid or alkali.