Examiners' Report
Principal Examiner Feedback

January 2021

Pearson Edexcel International Advanced Level
In Chemistry (WCH14)
Paper 1 Rates, Equilibria and Further Organic Chemistry (including synoptic assessment)

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Introduction

Some students were very well-prepared for this examination and scored high marks. Many students were able to demonstrate that they had a sound knowledge of the topics in the specification and could apply this to the questions with just a few errors or omissions. Other students found the paper very challenging and would benefit from much more preparation to ensure that they know the basic facts and can express their ideas clearly.

Section A

The mean mark for the multiple choice questions was 13.74%. The highest scoring questions were 8 and 13, with nearly 90% of students achieving these marks. The most challenging question was 3, with 47% of students achieving this mark.

Section B

Question 17

The majority of students were able to give a reason why lactic acid shows optical isomerism. A few students gave several reasons but if any of them was incorrect, this negated the mark. A few students also lost the mark by using incorrect terminology, for example, stating that there were four different molecules or substances joined to the central carbon atom. The majority of students also realised that a laboratory sample of lactic acid does not rotate the plane of plane-polarised light as it is a racemic mixture. Some stated that there would be two enantiomers but omitted that they would be in present in equal amounts. A few students wrote about the mechanism for producing a racemic mixture via a planar intermediate, but that was not necessary in this question. Only a small minority of students knew that concentrated phosphoric acid is a dehydrating agent so would remove the OH group from the central carbon atom and a hydrogen atom from the methyl group to produce an alkene.

Many students were able to identify X, Y and Z in (b) so scored full marks. Some careless errors, such as just stating or showing butanol for X and an incorrect number of hydrogen atoms on the substituted amide in Z, caused them to lose marks. Many students would benefit by reviewing the names of substituted amides.

The monomers in (c) were often correctly drawn but many students lost a mark by showing the OH groups on the left of the structures joined to the carbon incorrectly as OH-C. A few students showed a dialdehyde instead of a diacid. Some students showed the monomers as open-ended chains, which is incorrect.

Many students were able to work through the stages to identify E in part (d). A few did not give the molecular formula of E in (i) but tried to draw a skeletal or displayed formula. The majority deduced that E did not contain a carboxylic acid group and was an ester. Some did

not use all the spectroscopy data to deduce the structure of E and a few that did deduce the correct structure did not label the protons responsible for each peak. A common wrong answer was methyl butanoate, but this could still score
2 marks.

Question 18

The vast majority of students knew that the addition of a catalyst would have no effect on the value of the equilibrium constant. Many students deduced that the equilibrium yield of sulfur trioxide in (a)(ii) would decrease, although some were not awarded the mark as they just stated that the equilibrium position would shift to the left. Some students omitted to explain what would happen to the value of the equilibrium constant. The simplest explanation was in terms of the forward reaction being exothermic so the equilibrium constant will decrease but some students explained this in terms of entropy and this was acceptable. The expression for the equilibrium constant was written correctly by the majority of students but some omitted to show partial pressure, using P or PP, and others included square brackets which negated the mark. Many students calculated the equilibrium constant in (a)(iv) correctly. The common errors included: not being able to work out the number of moles of each substance at equilibrium, not calculating mole fractions or partial pressures, rounding intermediate values incorrectly, giving more than three significant figures in the final answer and omitting or giving incorrect units.

The unfamiliar calculation in (b)(i) was a challenge to many students but a significant number were able to work it out and score 1 or 2 marks. The majority of students were able to calculate the concentration of hydrogen ions from the pH of the solution. A few lost the mark as they rounded their answer incorrectly to 0.1 or 0.10 and some doubled it as they saw that sulfuric acid contains two protons. There were some excellent answers seen to (b)(iii) where the students realised that there will be a high concentration of hydrogen ions from the first equilibrium as it is almost complete and these will suppress the second equilibrium. However, there were many vague answers where the students did not make it clear which equilibrium they were writing about.

The majority of students knew that they needed to write one equation to show what happens when H^+ ions are added to the buffer solution and another to show the addition of OH^- ions. However, some added these ions to the wrong ions from the buffer solution. Some students wrote equations for the formation of sulfuric acid, which is not in the buffer solution. It was disappointing to see some students losing marks for writing incorrect formulae of ions, especially as these were given in the question, for example, sulfate ions shown as SO_4^- and hydrogen sulfate as HSO_4^{2-}. Although many students did score full marks for the calculation in (c)(ii), a significant number lost a mark as they seemed to think that they needed to subtract the moles of sulfate ions from the moles of hydrogensulfate ions but that was unnecessary in this calculation. Some students tried to do this calculation using the Henderson-Hasselbalch equation and, although this was acceptable, many of them could not remember it accurately and some substituted the concentrations for the acid and the salt incorrectly. The simpler method, using the expression for K_a as shown in the mark scheme, is recommended. Some students did not realise this was a buffer solution and tried to carry out the calculation by assuming that it was a weak acid.

Question 19

The majority of students could give the molecular formula of menthone. Some students would benefit from more practice at working out a molecular formula from a skeletal formula and others did not understand what was meant by a molecular formula.

Many students could draw an accurate mechanism for the reaction between ethanal and hydrogen cyanide in the presence of cyanide ions. Common errors included: not starting curly arrows from a lone pair of electrons or a bond, starting a curly arrow from the nitrogen in the cyanide ion instead of the carbon, omitting the negative charge from the cyanide ion, omitting the negative charge on the oxygen in the intermediate or also drawing a positive charge on the carbon atom. Some students did not read the question and started with menthone instead of ethanal.

Many students identified a methyl ketone from the iodoform test and the majority of them could then draw the skeletal formulae of four different methyl ketones. Some students did not read the question and wrote CHI_3 as the identity of the pale yellow precipitate instead of identifying the functional group in the carbonyl compound F and a few students tried to identify the compound. However, they could still receive credit for the skeletal formulae of the methyl ketones. Some students were confused between aldehydes and ketones. Many students identified F from the carbon-13 NMR information, but some did not identify the carbon atoms responsible for each peak. Students are advised to read and use all of the information given in the question and to check carefully that they have the correct number of carbon atoms in their skeletal formulae.

There were many excellent answers seen to the extended writing question in (d). Many students could identify the intermolecular forces present in each substance but they often did not compare the strength of these forces and relate them to the boiling temperatures. Although the majority of students identified London forces in all three substances, many did not state that the strength of these would be similar because they have similar numbers of electrons. Common errors included: stating that butanal has hydrogen bonding, discussing the hydrogen bonding between butanal and water or propanoic acid and water and thinking that covalent bonds are broken when these substances boil.

Section C

Question 20

Many correct answers to the calculation of the total entropy change in (a) were seen, with the working set out clearly. Some students calculated the entropy change of the surroundings and entropy change of the system correctly but tried to add them together in different units and a few students gave incorrect units.

The majority of students could show at least one half-life on the graph in (b)(i) but they were not all able to show or work out what the value of the half-life and 400 s was a common incorrect value for the second half-life. Many students realised that the reaction was first order with respect to bromide ions but they did not all state that this was because the half-lives were constant. Almost all students could deduce the order of reaction with respect to bromate(V) ions from the data in the table. The order of reaction with respect to hydrogen ions was more challenging but it was pleasing to see many students were able to do this. Many students lost marks in (b)(iii) as they did not read the question carefully and they omitted the bromide ions from the overall rate equation and/or omitted the units for the rate constant.

Students need to be more careful when plotting a graph to determine activation energy, such as the one in (c). Many lost marks by not choosing a suitable scale so that the points cover at least half the grid in both directions, having the ln*k* scale in the wrong direction, putting the axes the wrong way around and omitting the units for 1/T. Some students lost a mark as they only plotted the first and last points. The majority of students were able to work out the gradient of their line and the activation energy but many omitted the units of the gradient. Some students attempted to substitute values into the Arrhenius equation but were unable to solve it. It was disappointing to see some negative values for activation energy.

Summary

In order to improve their performance, students should:

- read the question carefully and make sure that they are answering the question that has been asked
- write concisely and avoid making the same point multiple times
- make sure that comparisons are made when required
- include all the hydrogen atoms when drawing displayed or structural formulae for organic compounds and make sure that the correct atoms are bonded together

- be careful with the precision of curly arrows in organic mechanisms, making sure that they start from a lone pair of electrons or a bond
- show all working for calculations and give final answers to an appropriate number of significant figures
- learn the reagents and conditions for the reactions in the specification
- practise answering extended writing questions
- reread questions and answers, where time permits, to avoid careless mistakes.

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