

A-LEVEL CHEMISTRY

CHEM4 Kinetics, Equilibria and Organic Chemistry
Report on the Examination

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General

The mean mark for this paper was higher than last year's paper but the general standard was similar. With most topics, students were able to score highly. However, questions which required more explanation or working in several steps or application to unfamiliar situations were found more difficult.

Students should again be reminded to use black ink so that scripts can be scanned successfully and be clearly and accurately read by examiners. Pencil should not be used and then written over as this often produces an unclear double image. There was also an increase this year in the number of questions answered both in the examination booklet and also on supplementary sheets but with neither attempt crossed out. Students should be aware that if two answers contradict each other, marks will be lost.

Question 1

Parts (a), (b) and (c) of this question were generally answered well, with the main error in part (b) being the inclusion of s^{-1} in the units and the main errors in part (c) being the omission or incorrect use of the volume and the incorrect rounding of $2.5/1.5 (= 1.666)$ to 1.6. In parts (d) and (e) respectively, most students correctly gave 'decrease' and ' T_1 ', but many struggled to give clear explanations, often repeating generic Le Chatelier statements rather than discussing these particular situations. The term 'favours' was not credited unless qualified.

Question 2

This question was generally well attempted, with most students scoring well in the mathematical sections. In part (a), most students gave the meaning of a weak acid as 'only partially ionised or dissociated into ions', and this was credited. The preferred answer was 'only slightly ionised'. 'Not fully ionised' did not gain the mark. The equation in part (b) was poorly answered mainly because the formula for sodium carbonate was incorrect. In some cases, the formula of sodium hydroxide or sodium hydrogen carbonate was given. A common error in part (c) was to omit the factor of 2 when calculating the concentration of hydroxide ions from the concentration of calcium hydroxide. Parts (d)(i) and (d)(ii) were answered well but in part (d)(iii) many students used an expression for K_c with $[H^+]^2$ or could not rearrange the correct expression to find the concentration of sodium benzenecarboxylate. Students should be encouraged to use words in their answers to make it clear whether the numbers they write refer to amounts in moles or to concentrations and also to which substance they refer. Answers to part (e) included many wrong substances and showed that some students think that H_2 (or H^+) is present in the atmosphere or that carbonic acid can exist in an alkaline solution.

Question 3

Most students scored highly on this question. Only part (b)(ii) proved difficult for some who were unable to calculate the new initial rate in part (b)(ii) either by dividing the given rate by 8 or by using their rate constant to calculate the new rate.

Question 4

In part (b)(i), only the highest-scoring students gave the simplest correct answer in terms of the benzene repelling the nucleophile ammonia but alternative answers were allowed, including a comparison of the strength or polarity of the C–Cl bond in chlorobenzene with that in a haloalkane.

There was also some confusion between identifying regions of high electron density such as lone pairs and delocalised electrons, and referring to benzene and ammonia as being negatively charged. Some students also wrongly discussed further substitution. Part (b)(ii) was well answered. However, reagents were needed in full, so Sn with HCl was required not just H^+ . Parts (b)(iii) and (iv) were also well answered. In part (b)(iii), 'concentrated' was needed with both acids to gain two marks, and M3 was often lost for the charge missing on $H_2NO_3^+$. The electrophilic substitution mechanism was generally well done although the positioning of the horseshoe representing delocalised electrons caused some problems in this example where the substitution did not occur at the carbon at the "top" of the benzene ring.

Question 5

In part (a), the nucleophilic addition mechanism was very well done; common errors included missing the charge on the nucleophile or on the intermediate structure and showing a bond between the carbonyl carbon and the N of CN in the intermediate. In part (b)(i), students were not used to drawing 3D structures, and credit was given where attempts showed a pair of mirror images. Again there were some problems with wrongly bonded OH, CN and CH_2CH_3 groups in these structures. The method needed to distinguish between two enantiomers was well known, although to gain M2 polarised light had to be 'rotated' not turned or reflected, and rotated in 'opposite' directions not just different directions. A few students suggested wrongly that the molecules polarised the light or that the molecules themselves were rotated. The name in part (c) was well answered but part (d) was answered poorly. There was confusion of K_a , the acid dissociation constant, with a rate constant, and many students missed the link to low concentrations of cyanide ions from the weak acid HCN and focused mainly on the rate of the dissociation of the acid. Parts (e)(i) and (e)(iii) were answered well but responses to part (e)(ii) sometimes included the C=C bond or the CN group as part of the polymer chain.

Question 6

Parts (a), (b)(i), (b)(ii) and (d) were very well answered, but formation of the ester in part (b)(iii) was less well understood. Just over a third of students scored both marks in part (c), but a mark was often lost where a displayed formula for the fragment ion was not shown. Other errors included omitting the charge and the radical dot on the molecular ion or including two positive charges on the fragment ion, ie writing C^+ in the structure and also writing + outside brackets around the ion. There were very few correct answers to part (e). Only a small number of students recognised that the amino acids would become protonated in acidic solution and so the protonated lysine would have twice the charge of the protonated alanine.

Question 7

Although many students scored well in part (a), answers were often badly expressed and very wordy. Most students gained M3 for explaining that the quartet was due to the CH_2 group being next to a CH_3 group and this mark was allowed even if the wrong ester was given. The question instructed students to use Table B on the Data Sheet, and it was only by doing this that M2 and M4 could be accessed and earned. Parts (b) and (c) proved very straightforward, although the full name "quaternary ammonium salt" was only given by a minority of students. A significant number of students who identified the correct reagent in part (c) either had the results reversed, or discussed cyclohexane and benzene in their answer, thinking that benzene would react with bromine.

Question 8

The nucleophilic addition-elimination mechanism in part (a)(i) presented a real challenge to many students, who were confused by the cyclic nature of the product, failed to identify the correct nucleophile and suggested either separate nucleophiles such as H_2O , CH_3OH and OH^- or alternatively loss of the proton from the OH group before nucleophilic attack. Most students gave the correct range for the carbon atom labelled **b**, but often the range for the carbon atom labelled **a** was given as 160–185 as for a carbonyl carbon. In part (a)(ii), the repeating unit for the polyester was answered well although some students gave twice the repeating unit.

The distinguishing test in part (b) was well done, although a significant number of students thought that substance **K** was an acid and wrongly suggested NaHCO_3 or Na_2CO_3 to distinguish between the compounds. It was common for students to fail to see the symmetry of **J** and so to predict, incorrectly, three peaks in its proton n.m.r. spectrum. Five peaks was a common incorrect answer for **K**, suggesting that students had misread the question and given the ^{13}C n.m.r. result.

Part (c) of this question proved to be very challenging and fewer than 10% of students scored full marks. Isomer **Q** was found particularly difficult where many students omitted one of the O atoms from their suggested structure. Other common errors included missing the double bond in **L**, giving the structure of **P** as the structure of **N** (which suggests a failure to recognise that optical isomerism is a form of stereoisomerism) or writing an unbranched carbon chain for the acid **N**. Answers to part (c) were often very badly presented, with a great deal of crossing out, duplication of answers and poor labelling of structures.

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