A-level

Chemistry

CHEM4 Kinetics, Equilibria and Organic Chemistry
Report on the Examination

2420
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General

Students are now very capable at answering the calculations in this paper, even those involving buffer solutions. Organic mechanisms are also frequently well answered. Despite this marked improvement over the life of the specification, the mean for this paper was slightly lower than last year reflecting the effect of a few more difficult questions.

Question 1

The calculation in part (a) was well answered and there were few errors although the units mark was occasionally lost. In part (b) the calculations were again well answered: experiment 3 involving a square root was the least well done. Marks were awarded consequentially on an incorrect value of k. Few students used the value of k of 2.3 supplied.
Here as elsewhere, students should be encouraged to keep their answer in their calculator as they work through a question and then write the final answer to the appropriate number of significant figures (usually 3).

The mark in part (c) proved elusive for many students, who referred to the rate of the reaction and not the mechanism as required by the question. It was well known that the concentration of **B** would not affect the rate, but how **B** was involved in the mechanism and the rate determining step was not well known.

Question 2

The expression and units for K_c in part (a) were very well done. The calculation in part (b) was fairly well done and those who did not gain 3 marks either could not rearrange the expression for K_c correctly or calculated the concentration of oxygen rather than the amount in moles as required.

In part (c) most students knew the effect and gained the first two marks. To score the third mark, students needed to explain that the equilibrium moved to reduce the increase in pressure that a flask of smaller volume would cause.

Question 3

Students showed a good understanding of this topic and part (a) was answered very well.
In part (b)(ii) some answers only showed one colour rather than the two seen in a colour change.
Part (b)(iii) was answered correctly by a narrow majority of students.

Question 4

The answers to part (a) were such that few scored both marks. Not only was the reason not well known, but a lot of wrong chemistry was written. Common errors included 'H_2O is completely ionised' and 'the concentration of water is 1'.

The answers to part (b) were slightly better and most students stated that the ionisation of water is an endothermic reaction, but a high number failed either to appreciate that this ionisation produces an equilibrium mixture or to explain that the equilibrium position moves to the RHS to oppose the increase in temperature.

Most students answered parts (c) and (d) well. A significant number of students used the K_w value for 25^{o}C, but this was only penalised once in the two parts. A small number failed to give their answer to the accuracy specified in the question (2 dp).

Question 5

In part (a) a mechanistic name was required not just nitration. In part (b)(i) many wrong reagents were given such as $NaBH_4$, and incomplete reagents such as HCl. Many student gave correct answers in part (b)(ii) but some equations were wrongly balanced and some included oxygen as a product.

Part (b)(iii) was answered correctly by few students. A common error was to miss out the 'making' of the product, J is used to make dyes, it is not itself used as a dye. Wrong products were also frequently given such as explosives, polymers or soap.

In part (c), the nucleophilic substitution mechanism, also in the AS specification, was answered fairly well. Common errors were to put a negative charge on the amine (this lost M1), to use bromoethane instead of bromomethane, (this lost M3) and to show the arrow in M4 going towards H. Students who drew the complete structure for **J** rather than RNH_2 were not penalised except in the extra time they spent in drawing it.

There were some good answers to part (d). The majority mentioned a lone pair, but did not always state that it was on the nitrogen atom. The mark scheme allowed many to score M2 when referring to **J** and then M3 when relating to **K**. Some students used the word 'dissociate' instead of 'delocalise'.

Question 6

The equation in part (a)(i) was fairly well written. By comparison, few students could name the ester correctly. The more common errors in the equation were to give a straight chain alkyl group in the ester, or to give the second product as water or to leave it out altogether. In part (a)(ii), the nucleophilic addition-elimination mechanism was well done with over half of the students scoring full marks.

In part (b)(i), the mark for 3NaOH was frequently scored, whereas the mark for the right hand side of the equation was often lost mainly due to mistakes in the salts, such as an incorrect number of hydrogen atoms, a covalent bond from O to Na, or covalent bonds between the three salts. Almost half of the students gained the mark in part (b)(ii). Those who lost it gave the carboxylic acid instead of the methyl ester or misread the question and calculated the Mr of the molecule rather than giving its formula.

Question 7

Part (a)(i) was very well done, although some answers included too many hydrogens on the nitrogen of proline. Part (a)(ii) was less well answered; some students drew the nitrogen atom either not in the ring or with a hydrogen atom attached. A few misread the question and used two proline molecules.

The name in part (b)(i) was well answered but that in (b)(ii) was found more difficult. Part (b)(iii) was answered correctly by about a third of the students. The most common error was not forming the polymer from a dicarboxylic acid and a diamine, but instead using amino carboxylic acids. A small number of students did not give the correct number of C atoms in the polymer section. Part b(iv) was well understood with strong C-C bonds being the most common correct answer.

Question 8

The straightforward question in part (a)(i) was well answered, although some students did not gain the mark as a result of failing to use all three pieces of data or of writing incorrect maths such as –360 – (–208) = +152. As expected part (a)(ii) was high scoring but part (b) was answered less well. In part (c) the data was often referred to as hydration and also as energy required to break the bonds rather than energy released as cyclohexane was formed.
The value for 1,4-cyclohexadiene in part (c)(i) was usually correct, but the possibility of partial delocalisation in the 1,3 diene in part (c)(ii) was not at all well understood. The predicted enthalpy of hydrogenation of the 1,3-diene was often given as the same as the 1,4-diene. In part (c)(iii) a mark for noting that the C=C bonds were closer in the 1,3-diene was often gained. However many students then went on to say in error that adjacent C=C bonds repel and so the 1,3-diene is less stable. It was rare to see a student apply their knowledge of delocalisation in benzene to the 1,3-diene, to deduce that partial delocalisation can occur here and, as with benzene, this causes some extra stability and so the enthalpy of hydrogenation is less exothermic than -240 $kJmol^{-1}$.

Question 9

The first part of this question was answered well and few students did not score all three marks. The most common error was in the rearrangement of the K_a expression. Some students subtracted the ethanoate concentration from the ethanoic acid concentration to give a wrong ethanoic acid concentration, although they could gain M3 for a correct pH consequential on their H^+ concentration.

Part (b) discriminated slightly better as there was scope for a variety of errors. These included using the values given in part (a), no addition or error in addition to give the new concentration of ethanoic acid, no subtraction or error in subtraction to give the new concentration of the ethanoate salt, wrong rearrangement of the K_a expression or a combination of these. Students were given credit for correct working where appropriate.

Question 10

Part (a) was answered well. "A simple test-tube reaction" was required so students lost the marks if they suggested that two reagents were added sequentially or two different reagents were used for **P** and **S**. The most common test used was acidified potassium dichromate(VI). A few students gave the observations the wrong way round.

The answer to part (b) was usually given correctly although a number gave acidified potassium dichromate(VI) again even though this also react with S. Part (c) was found to be more difficult. In part (d), most students gained at least two marks out of three. Tetramethylsilane was well known but often given as a structural formula or even as a displayed formula when the molecular formula was required. A few students referred to the proton nmr spectrum rather than the ^{13}C.

There were some good, well explained answers to part (e). The spectrum in Figure 2 was usually identified as **R**, but the spectrum in Figure 3 was less well answered as **T**. The data sheet was used well, but the terms ester and ether from Table C on the sheet were sometimes muddled. Students who were unable to state correctly which isomer produced each spectrum could not access the explanation marks. Isomer **S** was the most common incorrect answer for Figure 3. Better students appreciated that the spectrum of **T** would show two C-O peaks in the region 50-90 ppm but **S** would only have one of these and then used the two peaks in this region of the spectrum to confirm their choice.

In part (f), compound **U** was often correct. There are many cyclic alcohols of $C_6H_{12}O$ which exist as optical isomers and most were seen and gained credit. Common incorrect answers were **S** itself and the optically inactive 1-methylcyclopentan-1-ol and cyclohexanol.

Question 11

This question discriminated well with only the most able students able to score full marks. Steps 1 and 2 were generally well done but step 3 proved more of a challenge. The reagents in steps 1 and 2, HBr and NH_3, were well known, but wrong reagents were penalised as a chemical error and lost the product mark as well. A common error was to give 1-bromobutane as the product in step 1, and this chemical error earned a two mark penalty, but the product in step 3 could gain the mark consequentially.

Many students were unable to state a correct reagent in Step 3 and so could only access the mark for the mechanism in this step.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.

Converting Marks into UMS marks

Convert raw marks into Uniform Mark Scale (UMS) marks by using the link below.

UMS conversion calculator www.aqa.org.uk/umsconversion