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Chemistry CHEM4

(Specification 2420)

Unit 4: Kinetics, Equilibria and Organic Chemistry

Report on the Examination

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General Comments

Overall the paper was found easier than that of January 2011 and the mean mark was almost eight marks higher. There were many excellent answers to both organic and physical chemistry questions.

Question 1

The kinetics question was, as usual, answered well with only Experiment **4** in part (a) causing much difficulty. However, in part (c) fewer than half of the students identified graph G as that correctly showing how the rate constant *k* varies with temperature.

Question 2

The first three sections of part (a) were well answered, but in part (a)(iv) a large number of students failed to convert moles into concentration. Some also over-rounded numbers at an early stage and this led to answers outside the accepted range. Part (c) proved more challenging, with a very large number of students giving T_2 as the higher temperature.

Question 3

Almost all students scored the mark in part (a), but in the rest of the parts of this question, there was less good understanding of the chemistry of weak bases and the operation of basic buffers. There were many incorrect answers in part (b)(i) where ammonia and ethanol were often given as the products of the reaction. This led to wrong answers to part (b)(ii). A number of students wrote ‘inductive effect’ in part (c) without any mention of what this applied to; the final mark was, however, often scored. Part (d) proved to be very difficult and although, in part (e), many students recognised that the added H^+ ions would react with OH^- ions in the solution, a large number failed to explain how the buffer would respond to this reaction.

Question 4

All of the pH calculations in this question were answered well. In part (a), more students than expected had difficulty calculating the $[H^+]$ after dilution but a mark was allowed for a correct calculation of pH from their $[H^+]$. In part (b)(ii), some students struggled to convert the pH into $[H^+]$ but over three quarters of the entry gained all three marks. In part (c), common mistakes included using the initial number of moles of OH^- rather than those remaining after partial neutralisation and also not using the total volume to convert the number of moles of excess hydroxide into a concentration. The degree of clarity of some students’ working was also disappointing; many wrote strings of numbers with no explanation of what they were calculating. As usual, students who made errors in their calculations or gave a wrong answer with no explanation or working could gain few marks.

Question 5

All parts of this question on Mass Spectrometry were answered well, especially part (c). In part (a), an ion or radical with *m/z* =133 was sometimes given rather than a hydrogen radical. In part (b), an oxygen radical or an oxide ion $O^–$ were suggested quite frequently. Over half of the students correctly identified all four spectra in part (d).

Question 6

Part (a) was fairly well answered although many lost this mark as they did not specify that the O–H group was in an alcohol. However, students found parts (b)(i) to (b)(iii) quite challenging, often having difficulty expressing their answers clearly if they tried to describe the grouping present in words. Many ignored the integration value and simply copied directly from the Data Sheet. Occasionally, students who had failed to score in parts (b)(i) to (b)(iii) gained the mark for the overall structure in part (b)(iv) while others ignored the information from part (a) that compound **X** contained an alcohol group.

Question 7

In part (a), many students expressed concern that the products of hydrolysis would be carcinogenic because they contained a benzene ring, but otherwise this was well done. Strict adherence to IUPAC names made the mark harder to gain in part (b) where many missed the 'e' from the name. Parts (c) and particularly (d) were very well done and better than similar questions in previous papers. In part (e)(i), many students could not write a correct definition, often relating their answer to optical isomerism alone. Many also failed to recognise that two stereoisomers will have the same structural formula and not just the same molecular formula. Nearly half the students scored both marks in part (e)(ii).

Question 8

Although in part (a) many students scored all 3 marks, part (a)(ii) was the least well answered. Some students gave a general use for an ester rather than a specific use for this type of ester. Parts (b)(i) and (ii) were well answered, but many students failed to score in part (b)(iii) about melting points because they discussed breaking amide or ester bonds or alternatively stated incorrectly that the polymers were ionic.

Question 9

About half of the students scored all three marks in part (a)(i); the main errors were not stating that both acids needed to be concentrated and also failing to balance the equation. The mechanism in part (a)(ii) was also very well done, although some students attempted to produce the trinitro- compound and often the intermediate shown had the nitro group attached to the wrong carbon atom. In part (d), many students assumed that this was a combustion reaction rather than the decomposition stated in the question, and, disappointingly, 6N often appeared rather than $3N_2$ in an otherwise correct equation.

Question 10

These mechanisms were well done and clearly presented with about a third of students scoring full marks. However, many struggled to name both compounds correctly. Propanamide proved especially difficult, with incorrect names based on aminoketone appearing very frequently. There were some good answers to part (c), but many others involved comments about ammonia not being attracted to the benzene ring rather than actively being repelled by it. 'Ammonia is a nucleophile' was another frequent wrong answer.

Question 11

This three-step synthesis was slightly easier than the three-step synthesis in last year's paper. The question discriminated very well; there were many excellent answers and some very poor ones, too. Many students were able to see their way through this synthetic route and had clearly learned reagents and types of mechanism very thoroughly. Others struggled to get started. Common errors included giving L as propan-1-ol, naming M as prop-2-ene, omitting the concentrated condition from sulfuric acid and calling the mechanism in step 2 dehydration rather than elimination.

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