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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 June 2011 and the mean mark was seven marks higher. There were many excellent answers to both organic and physical chemistry questions.

Question 1

Most students scored highly in this question apart from part (a)(iii) where many repeated the mathematical information given in the question (that the units cancelled) and did not give a chemical explanation (that the number of moles on each side of the equation was equal). Part (b) was answered well with parts (i) and (iii) proving easier than (ii) and (iv).

Question 2

As is usual with kinetics questions, this produced some high marks, with many students scoring full marks. In part (a), the more tricky calculation for Expt 4 was least well done and in part (b) the most common mistake in calculating the value of *k* was to forget to square the concentration of **P**.

Question 3

Part (a) was well known, but part (b) was much less well understood. In part (c), most students scored the first two marks but then failed to use their answers correctly to calculate the total volume. Some who did not read the question fully, added 25 cm^3 to their correct answer and so lost the final mark.

In part (d)(iii), a significant number could not correctly rearrange the simplified expression for K_c. A mark was allowed, in this part only, for a correct calculation of pH using their value of $[H^+]$ even if this was not the correct concentration.

In part (e), most scored the first two marks, but many then failed to recognise that, on adding alkali, the number of moles of acid would have decreased. Others were unable to rearrange the K_a expression correctly or attempted to use the equation $K_a = [H^+]^2/[HX]$.

Moles and concentration were often confused and many responses were also badly presented with little explanation. Such omission makes it difficult for examiners to award marks in an extended calculation if the answer is wrong.

Question 4

In part (a), the mechanism was frequently correct and well presented, but some students lost a mark by writing a minus charge on the oxygen of methanol. Methyl ethanoate was a common wrong name for the product ester.

There were few correct answers to part (b)(i); IUPAC nomenclature requires an ‘e’ before the numbers. Many correctly identified the diacyl chloride in part (b)(ii) but some failed to give its displayed formula. Although hydrolysis was often correctly identified, part (b)(iii) proved to be difficult, with many offering the breaking of peptide bonds as an explanation and very few identifying attack by the hydroxide ion on the electron deficient carbon as a contributory factor. Part (c)(i) was very well done although a few lost the mark by drawing incomplete structures, notably by omitting the oxygen in the OH of the acid group so giving an aldehyde.

Despite the question in part (c)(iii) stating 'other than cost', many students still gave the answer that the anhydride is cheaper. Another common wrong answer was to describe the loss of chlorine rather than hydrogen chloride. Part (d) was correctly answered by half of the students; some of the others lost the mark by careless omission of an oxygen atom and so drew a ketone rather than an ester.

Only the weakest students failed to answer parts (e)(i) and (e)(iii) correctly, but only the top 20% were able to deduce the number of ^{13}C peaks correctly in part (e)(ii).

Question 5

The mechanism in part (a) was well presented and correctly answered by the vast majority but careless omission of the minus charge on the cyanide ion lost many the first mark. Other errors included drawing curly arrows which did not start at a lone pair on oxygen in the intermediate and also showing the arrow indicating loss of the proton from the intermediate going from the bond to the H atom.

In part (b), many missed the 'e' from the name and in part (c) several suggested that 'acidic' was the condition to use with the reagent ammonia.

Although most students correctly recognised the presence of a zwitterion, the mark for part (d)(i) was sometimes lost because of careless presentation. The bond from the central carbon atom must join to the CH_2 of the ethyl group, not the CH_3, and the bond to the carboxylate group must join to the carbon and not an oxygen in the group. Part (d)(ii) proved difficult and often careless use of the terms "molecule" or "intermolecular forces" lost a student both marks.

The structure in part (e)(i) was well done. Part (e)(ii) proved more difficult with students often offering structures which were neither an amide nor a tertiary alcohol. A significant number omitted part (e)(iii) completely and often **X** itself was given as the answer. Part (f) was found difficult; quaternary ammonium salts and compounds containing Br were common wrong answers and other students lost the mark because of careless drawing of the structure.

Question 6

In part (a), the mechanism was generally well answered, but the equation to show the production of aluminium chloride and hydrogen chloride was often missing. Very few students were able to name the product correctly in part (b).

Part (c) was well done but in part (d) some students appeared to think that in methylbenzene the methyl group would be substituted rather than one of the hydrogen atoms. However, the better students were able to use their understanding of the inductive effect of alkyl groups to suggest that the electron density on the ring in methyl benzene would be increased and go on to suggest how this would increase the rate of reaction.

Question 7

There were many excellent answers to part (a) of this question. Common errors in what were otherwise correct answers for part (a) included incomplete reagents such as omission of the acid with potassium dichromate or simply stating "carbonate" rather than the full name or formula of a carbonate such as sodium carbonate or Na_2CO_3.

The haloalkane proved to be the most difficult to identify, with students often treating it as an acyl chloride and assuming that addition of water would give misty fumes.

A single test was required for each compound so answers which involved a preliminary step before a test did not score.

In part (b), the first two marks were often gained but few students gained both of the other two. This was often because of incorrect or missing statements about polarity in propanone or propan-2-ol or because of a lack of knowledge of what is happening in this type of chromatography. Many students thought that the substances would rise in the column while others thought that the M_r would affect retention time.

Question 8

Part (a) was answered correctly by over half of the students. Careless representation of the C–NO_2 bond lost some students a mark from otherwise correct structures.

The remaining parts were found harder. In part (b), benzene was often given as an incorrect structure for **J**. Missing hydrogen atoms and non-cyclic compounds often lost students marks in part (c), especially for substance **L**.

Students struggled with part (d) and an appreciable number omitted this part completely. Although **M** was identified more frequently than **N**, students demonstrated, as in previous examinations, their lack of understanding of the structures of secondary and tertiary amines.

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