Version 1.0

General Certificate of Education (A-level)
January 2013

Chemistry CHEM4

(Specification 2420)

Unit 4: Kinetics, Equilibria and Organic Chemistry

Report on the Examination

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General Comments

Overall, this paper was found to be slightly easier than the January 2012 paper and the mean mark was 1 mark higher. There were many excellent answers to both organic and physical chemistry questions.

Question 1

This question was answered well by most students and over 80% scored full marks in part (a). Part (c)(ii) was found slightly harder and, of those who correctly identified Step 1 as the slower step, most gained the mark for the curly arrow. Those who suggested Step 2 could also gain a mark for a correct arrow for that step. However, many gave a full S_N2 mechanism in both cases.

Question 2

Students found part (a) relatively easy. The most common errors were in part (a)(iii) where some students squared the hydrogen ion concentration.

The double arrow sign for an equilibrium was frequently missed in part (b)(i) and there were several instances where the wrong proton was lost from HCOOH. Only 33% of students scored all 3 marks in part (b)(iv). Some students lost M1 for confusing higher $[H^+]$ with higher pH. Some lost M3 because they wrote an explanation in general terms, "according to Le Chatelier's principle" rather than suggesting that the position of equilibrium shifts to oppose a specific change, ie to reduce the temperature.

Part (c) was a good discriminator and the full range of marks was seen, although there were more than usual who gained high marks in what has, in the past, been seen as a difficult topic. In part (c)(i), some students couldn't rearrange the K_a expression correctly and wrote the acid and salt concentrations the wrong way round. Many calculated an 'excess' of methanoic acid by subtraction.

The calculation in part (c)(ii) proved to be the most difficult calculation on the paper. Most students scored M1, but several wrote nothing further. Many also gained M2 although adding and subtracting the wrong way round caused many to lose any further marks. Incorrect rearrangement of the K_a expression was again a problem.

Question 3

Full marks were scored by 50% of students in part (a)(i); the most common errors were omitting the 3 on the left-hand side and including an extra H on C2 of propane-1,2,3-triol.

In part (a)(ii) several didn't note the two O atoms in the ester so gave 28.5 instead of 27.5 for the moles of oxygen.

Part (b)(ii) proved to be quite difficult with 27% of students scoring 0. By contrast, parts (b)(iii) and (iv) were found to be relatively straightforward and over 80% gained full marks.

Question 4

Part (a)(i) was only answered correctly by 28% of students but the rest of part (a) was well done including the name in part (a)(iii) although some had the prefixes in the wrong order or had the numbers reversed.

Part (b)(ii) was not well done. As noted in previous reports and also in the **General Principles applied to marking CHEM4** document included at the end of every mark scheme, the 'e' is required in the names of diols, triols etc as in the example here, propane-1,3-triol.

There were very few wrong answers in part (c).

Many students scored 1 mark in part (d) for identifying the correct compound as 'c', but the explanations were almost always incorrect. The C-F bond in the copolymer is polar but is not hydrolysed because it and all other bonds in the compound are strong.

Question 5

Only 21% of students gained both marks in part (a)(i). A surprising number repeated inert or non-toxic despite these properties being stated in the question.

Students found part (b) hard. Many failed to use all three pieces of information in each case and an appreciable number thought the compound was an ester.

Part (c)(i) was well done but (c)(ii) proved to be very difficult. Many gave structures with 5 or 7 C atoms. In part(c)(iii), many suggested structures that contained benzene rings and some contained no O atoms while others contained N atoms.

Question 6

This question was answered well with about two thirds of students scoring full marks. Common errors included incomplete reagents, such as omitting the acid used with potassium dichromate and giving just the name of the product without any observation as required.

Question 7

In part (a), many students thought $NaBH_4$ or $LiAlH_4$ could be used as the reducing agent. Most did not give the molecular formulae in the equation but could balance it correctly; the repeating unit of the polymer was very well done.

Similarly, in part (b), $NaBH_4$ was often suggested as the reducing agent and the empirical formula was frequently wrong. Students found the bond angles difficult, with many failing to deduce that there is a tetrahedral arrangement around a C atom in cyclohexane and appearing simply to guess any angle. Only the most able scored both marks for the bond angles.

There was a good spread of marks in the mechanism with over 40% gaining full marks. In part (c)(ii), most realised that the product was a racemic mixture and that it was produced as a result of attack on the ketone from both sides, but often this was thought to be by an electrophile or an H^+ ion. Some thought that a carbocation intermediate was attacked.

Question 8

In part (a)(i), only the most able could write a correct overall equation and name the product correctly. Marks awarded for the electrophilic substitution mechanism were high although some students were careless in their drawing of the Wheland intermediate, particularly the position of the + in the hexagon.

The definition of a nucleophile was not well answered in part (b). Many realised that nucleophiles have a lone pair but failed to mention that they could donate them; others

offered a description in terms of attraction to an electron rich area.

The structure of the organic product was well attempted but many failed to recognise it as an acid anhydride, often suggesting that it was an ester.

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