A-LEVEL
CHEMISTRY

7405/3
Report on the Examination

7405
June 2017

Version: 1.1

General comments

This new paper 3 examination, with its concentration on synoptic and practical chemistry and inclusion of thirty objective questions, is significantly different from previous A-level chemistry examinations. The performance of students was pleasing. The exam differentiated well; the mark distribution showed a good 'bell-shaped curve' around a mean of 53%, with a maximum mark of 88/90 (achieved by a single student). Although every single mark on the paper was achievable, only 1% of students scored both marks for question 03.7 and only 6% scored both for 04.6. This indicated that students had some difficulty in understanding the principles behind their practical work.

There are some features of student performance in this exam that, if attended to, would lead to an improvement:

- It is not good practice to start an answer by repeating the question (e.g. question 03.3 was 'suggest why an excess of sodium hydroxide is used' and many answers began with the phrase 'an excess of sodium hydroxide is used because…'). This approach uses up space on the answer lines unnecessarily and, more importantly, wastes time that could be used more effectively.
- Apparatus lists are not required with practical descriptions. Each piece of apparatus should be mentioned in turn as and when it is used in the method.
- Students should take care not to offer two differing answers to a question. If one answer is correct but the second is incorrect, the mark will be negated by the incorrect answer.
- When generating intermediate answers in a calculation, it should be clearly indicated to what the number refers. For example, many of the calculations in question 01.4 were poorly laid out, making it difficult for examiners to identify which number on the page students were offering as the calculated gradient.
- If additional pages are used, the questions should be clearly numbered and any rough work should be clearly crossed out.
- The instructions for completing the answers to Section B are clearly explained at the start of the section. Despite this, a significant minority of students did not follow them, which resulted in many scripts having to be marked manually. Sometimes marks for these questions were lost due to there being apparently multiple answers, or answers not clearly indicated.

Question 1

01.1 This proved to be a much tougher starter question than had been anticipated, with only 12% of students earning the mark. Students did not recognise that enthalpy change could not be measured directly. In this case, the enthalpy change was for the formation of a hydrated salt from an anhydrous one – with the expected answer being that it would be impossible to prevent some salt dissolving during the addition of water to the anhydrous salt. An alternative answer, related to the difficulty in measuring the temperature of a solid, was also allowed (but see question 01.3).
Some students' answers revealed confusion between calorimetry and colorimetry, with suggested answers including the fact that there is no colour change during the reaction.
Some students also seemed to believe that calorimetry is only possible if something is being burned.

01.2 This calculation was answered reasonably well, with less than 20% of students failing to score. There was confusion about the 'direction' around the Hess Cycle, and evidence that many students think that an equation of the form $\Delta H = \Sigma\Delta H_f$(products) - $\Sigma\Delta H_f$(reactants) can be used universally, when it only applies to the specific use of enthalpies of formation.

01.3 Most students' encounter with this 'extended response' style of question produced a good spread of marks, although 37% of students failed to score. This was usually due to a completely inappropriate method being described, with incorrect answers seen that included: "making a solution of magnesium chloride", "using it to fill a spirit burner and lighting it under a beaker of water" and "putting a solution of magnesium chloride in a polystyrene cup and heating it over a Bunsen burner". Other incorrect answers included descriptions of the preparation of a standard solution followed by a titration, and the addition of magnesium chloride to acid instead of to water.
This question was marked using a 'levels of response' mark scheme. The key to success was for students to concentrate first on the inclusion of as much correct chemistry as possible to ensure access to Level 3 (worth 5 or 6 marks). Within a level, the mark awarded depended on the clarity and coherence of an answer, together with a clear, logical progression through the description. Appropriate apparatus and quantities should have been mentioned as necessary. For example, rather than writing 'add water to a container', a good start to the answer would be to write 'A measuring cylinder was used to measure 50 cm^3 of water into a polystyrene cup'.
Despite the fact that many students suggested, in question 01.1, that it is difficult to measure the temperature of a solid, many then suggested putting the magnesium chloride into the polystyrene cup first and then recording its initial temperature, before adding the water.

01.4 This was a challenging question but one for which it proved relatively easy to score two marks; nearly 20% of students scored full marks here. Most students could successfully plot the points and draw a best fit line, although the negative scale on the y-axis confused some. Most students were also able to calculate the gradient of their line, although, as mentioned previously, it was not always clear what their suggested answer was. The calculation of ΔS proved trickier, with many trying to use the relationship $\Delta G = \Delta H - T\Delta S$, and either ignoring their calculated gradient or substituting it in for ΔH. Relatively few students recognised that this equation can be taken as y = mx + c (y = c – xm in this case) so that this graph of ΔG (y) vs T (x) gives a straight line with a gradient of $-\Delta S$.

Question 2

02.1 78% of students gained this mark.

02.2 With nearly 40% of students scoring full marks, this question illustrated that the skill of representing mechanisms is good. When confusion arose it generally involved attempts to show mechanisms involving water and producing the alcohol, when the final product in this case should be propyl hydrogensulfate. The most common omissions were the curly arrow to show breaking of the H-O bond in H_2SO_4 and/or the negative charge on the HSO_4^- ion. The bonding/order of atoms in H_2SO_4 was also sometimes confused, with structures such as H–O–HSO_3 seen.

02.3 Most students who showed a secondary carbocation structure in question 02.2, were able correctly to show the structure of a primary carbocation here. If a primary ion structure had been shown in 02.2, 'ecf' was allowed for those (relatively few) students.

02.4 Most students gained the first mark here, but only 17% achieved full marks. A simple statement that a secondary carbocation is more stable than a primary was sufficient for the first mark (although many students mistakenly referred to the greater stability of the final product instead). For the second mark, the explanation needed to make clear that the positive inductive effect was greater in the secondary carbocation due to it having **more** alkyl groups attached to the C+.

02.5 This was another question that proved trickier than expected, with a roughly even split between 0, 1, 2 and 3 marks. 'Butan' or 'bute' were often seen as incorrect stems of names and a very common error was for the same isomer of but-2-ene to be drawn twice, with one named as *Z*-but-2-ene and the other as *E*-but-2-ene.

02.6 Butanal was a common wrong answer for the by-product and the fact that sulfuric acid acts as an oxidising agent was not well recognised.

02.7 Although the oxidising ability of concentrated sulfuric acid did not seem to be recognised often in question 02.6, it was often, incorrectly, suggested here, with most students concentrating on this aspect and failing to recognise that sulfuric acid does not oxidise a chloride ion.

02.8 Over 30% of students gained full marks here, but there was also quite a lot of confusion between the products, with carbon suggested as the black solid; iodine, SO_2 or H_2S as the yellow solid; and SO_2 commonly suggested as the gas smelling of bad eggs.

Question 3

03.1 This question, and others in question 3, illustrate the importance of students paying attention to **why** certain techniques and processes are used during practicals. The role of anti-bumping granules was not as well understood as expected, with only 30% of students gaining this mark. Incorrect suggestions included that they slow the reaction down by preventing the reactant particles from bumping into each other.

03.2 This proved to be an easy question for most, although there were issues with the layout of the calculation; it was not always clear which calculation related to which reactant.

03.3 Nearly 60% of students gained this mark but a lack of specific clarity cost many dearly. Many students apparently did not retain an awareness of the context of a question as they worked through the stages. They did not appear to recall, from the stem of the question, that the reaction was between NaOH and ethyl benzoate. This recall should have enabled students to make the specific statement that the excess of sodium hydroxide was to ensure that all the ethyl benzoate would react.

03.4 Answers here often incorrectly referred to the 'control' of the temperature rather than recognising the risk of flammability of organic reagents. Clarity is again key, because any suggestion that NaOH is flammable is incorrect.

03.5 As was also evident in question 02.6, some students thought that reflux is a separation method. A specific answer was again the key here, with a need to mention the fact that reactant/organic **vapours** are returned to the reaction mixture. Suggestions that reflux prevents vapour forming were incorrect.

03.6 This was answered best by students who used structural or partial skeletal formulas. Many students, who attempted to use molecular formulas, often miscounted the number of hydrogens or carbons. Care was needed to avoid any suggestion that there is an O–Na bond in sodium benzoate.

03.7 As mentioned previously, this proved to be the trickiest question on the paper, with only 1% of students earning both marks. Most could state that sodium benzoate is ionic – although there were also many incorrect references to it being ‘polar’ or ‘a molecule’. However, a proper description of why benzoic acid is insoluble was beyond most students. Many stated that it is non-polar, while others suggested that its ability to hydrogen-bond with itself is what prevents it dissolving. Very few were able to clearly explain that, despite the polarity (and hence the ability to form hydrogen bonds with water), the large non-polar benzene ring prevented dissolving.

03.8 About a third of students earned 4 or more marks here, but about the same number failed to score. Despite a statement in the stem that benzoic acid is a solid, many answers referred incorrectly to methods based on distillation and/or solvent extraction. Some answers implied that a solid would be expected to run through the tap of a separating funnel! For those students who correctly recognised that recrystallization was the correct method, there was often confusion in the order of the steps, which prevented potentially good answers gaining full marks. An example seen quite often was the suggestion that the solid obtained after cooling/crystallisation should be washed **before** filtering. The steps most often missing were the need for hot filtration after dissolving the impure solid in hot solvent, and the final wash and dry after Buchner filtration.

03.9 This was another tricky question, with only 10% of students earning full marks. It seemed that many were thrown by the realisation that the answer was over 100%, with many students responding by doing the percentage calculation the wrong way round, because they seemed to feel that the answer must be less than 100%. Relative molecular masses were often calculated incorrectly despite that for ethyl benzoate being given in the stem. The M_r of ethyl benzoate was sometimes used in place of the M_r of benzoic acid.

Question 4

04.1 Nearly 60% of students recognised that the working range should correspond to the vertical section of the titration curve.

04.2 Over 80% of students recognised this expression, with the commonest error being to show it as $[H^+]^2/[HX]$.

04.3 This question was another that illustrated the importance of paying attention to the information in the stem of a question. A significant number of students attempted to answer this question using the expression for K_a, instead of recognising that this is a titration and that the end-point allows the amount of NaOH to be calculated, and hence the amount and concentration of the acid. Perhaps students did not recognise that that the end point of the titration could be obtained easily from Figure 1.

04.4 The provision of alternative data ensured that students who had difficulty with question 04.3 were not disadvantaged here and over 50% gained full marks. Data in the stem were again crucial here.

04.5 The idea that pH = pK_a at half-equivalence was not recognised by many, so only 26% of students gained this mark.

04.6 A mark was often lost as a result of students assuming that half-equivalence was at 10 or 15 cm^3 and so plotting incorrectly. Many also failed to remember the need to show an initial steep section before buffering ‘levels off’ the curve.

Use of statistics

Statistics used in this report may be taken from incomplete processing data. However, this data still gives a true account on how students have performed for each question.

Mark Ranges and Award of Grades

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