A-LEVEL
CHEMISTRY

7405/3: Paper 3
Report on the Examination

7405
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General Comments

The third sitting of this exam again resulted in pleasing differentiation, with a good ‘bell curve’ around a mean of 57% (3% up on last year’s mean) and a range of marks from 89 down to 0.

Fully correct answers were seen to every question on the paper, although only around 5% of students scored full marks for 01.4, the level of response question.

Students are offered the following advice.

- It is not good practice to start an answer by repeating the question.
- They should not include apparatus lists with practical descriptions. Each piece of apparatus will be mentioned in turn when it is used in the method, so does not need a separate listing.
- They must not offer two alternative answers (even if one is on separate paper), since, if one answer is correct but the second is incorrect, the incorrect answer will negate the mark.
- When generating intermediate answers in a calculation, it should be clearly indicated what the number refers to. For example, many of the calculations in 02.4 were poorly laid out, making it difficult for examiners to identify which number corresponded to the amount, in moles, of hydrogensulfate ions or the concentration of hydrogensulfate ions.
- 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, for changing answers from correct to incorrect and vice versa, 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 checked manually due to there being apparently multiple answers, or answers indicated by the wrong method. Attempts at answers should not be ‘rubbed out’ as the ‘rubbed out’ answer can still be picked up during scanning and make it appear as though two answers have been suggested. It was surprising to see how many students in section B suggested two possible answers for some questions; students should be aware that there is only one answer to each question in section B.

Section A

Question 1

1.1 This proved to be a tougher start than anticipated. Many students were unable to translate this GCSE skill into this less familiar context, with a common incorrect equation being:

$$Na^+ + Cl^- \rightarrow NaCl$$

1.2 A reference to ‘acidity’ was often seen for the first mark, but a correct equation was much less commonly seen. Many students attempted to write an equation showing the formation of H_2SO_4 instead of H_2SO_3.

1.3 A significant minority of students showed either one lone pair or none on the O atom in the water molecule and quite a few based their explanation of the bond angle on a 'starting point' of 180°. Students should be reminded that the starting point for this discussion is the total number of electron pairs (4 = tetrahedral, 109.5°), with the final shape and angle depending on the balance between lone pairs and bond pairs plus the fact that repulsion due to lone pairs is greater than that due to bond pairs. In this case, the presence of two lone pairs reduces the angle from 109.5° to 104.5°.

1.4 Greater student familiarity with this style of question, and probably also a more recognisable practical scenario, meant that this question, marked by judging a level of response (LoR), proved more accessible than in previous years. Approximately 17% of students scored in level 3 (compared with about 9% last year) and only around 17% of students failed to score.

There were, nonetheless, some strange choices of experimental method suggested. As the equation had been given earlier in the question, it was surprising to see that several students suggested using a gas syringe to collect the sulfur gas formed! Another 'popular' incorrect choice was to suggest carrying out the reaction on a balance to record the increasing mass as sulfur was formed.

Many students still struggle to organise their answers adequately. LoR questions are marked using 'levels' and the key to success is 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 depends on the clarity and coherence of an answer, together with there being a clear, logical progression through the description. Appropriate apparatus and quantities should be mentioned as necessary, so, for example, rather than stating 'add thiosulfate and acid to a container', a good start to the answer would be to write, 'Measure equal volumes of sodium thiosulfate and hydrochloric acid of known concentrations into separate beakers using measuring cylinders'.

Unless specifically asked to suggest suitable volumes/concentrations, then it is sufficient for students to indicate that they would make a measurement without needing to state a value. Many answers were unnecessarily complicated by elaborate descriptions of water baths; we would suggest that the best way to describe a procedure such as this would be to describe the method with reference to an initial experiment at room temperature. Once the key parts of the procedure have been described, the student simply then needs to say that 'the experiment is repeated at several different temperatures using a water bath to heat the solutions before mixing'.

The most common reason for students failing to access level 3 was that they failed to make any mention of rate; instead, having described recording times at various temperatures, many then suggested plotting a graph of time against temperature.

Question 2

2.1 A clear majority of students were successful here, with the commonest omission being the bond between the O and H in each of the O–H groups.

2.2 The stem of the question clearly stated that H_2SO_4 is a strong acid and HSO_4^- is weak, but many students failed to draw both arrows correctly. The 'strong' nature of H_2SO_4

necessitated the use of a one way arrow (→), while the 'weak' nature of HSO_4^- required an equilibrium arrow (⇌).

2.3 With only around 23% of students scoring full marks on this description of a familiar procedure, it was a lack of detail and clarity that let down many. Descriptions of 'weighing by difference' were many and varied, with some students ending up contradicting themselves by adding washings from the weighing boat (which is a possible method) but then also re-weighing (which would not then be valid as there would be water in the weighing boat at this point). Weighing straight into a beaker is a valid approach, as is weighing directly into the volumetric flask but, in either case, an initial weighing (or tare) needs to be described.

2.4 Hardly any students scored full marks for this question. Very few students seemed to appreciate that, when calculating pH using an expression of the form $K_a = [H^+]^2/(c\text{-}x)$, the value of 'x' must be much smaller than the value of 'c' if it is to be ignored. In this case, the $[H^+]$ can be calculated from the pH and it is equal to x, the concentration of sulfate ions. The equilibrium concentration of hydrogensulfate ions can be calculated by subtracting x from the initial $[HSO_4^-]$. The inference from the method chosen by most students is that this type of calculation tends to be done by rote rather than by applying an understanding of the chemical principles involved.

2.5 With around 50% of students failing to score, this question proved trickier than expected. Many students failed to realise that this should be answered with reference to the equilibrium equation from earlier in the question. There was also evidence of confusion between the direction of change in pH and the corresponding direction of change in $[H^+]$, with many suggesting that an increase in pH represents an increase in $[H^+]$. Explanations for an increase in pH also often featured the suggestion that $[OH^-]$ must be increasing – a misconception perhaps derived from the GCSE idea that an alkali contains OH^- ions and that this explains high pH values. At A-level it would be hoped that students recognise that the pH scale is a measure of $[H^+]$ and that high values represent low $[H^+]$.

Question 3

3.1 As expected, this gave students an easy introduction to question 3.

3.2 Again, this was well answered, with relatively few suggesting, incorrectly, that the salt bridge allows electrons to flow through it.

3.3 The presence of the Fe^{3+}/Fe^{2+} electrode meant that some students suggested an iron electrode here, but most recognised the need for an inert, platinum electrode.

3.4 A surprising number of students failed to score here, with a significant number of responses showing no concept of what was required, especially in the 'conditions' column. Of those students who made a reasonable attempt, there was some confusion about the significance of concentration with the $[H^+]$ in **C** needing to be 1.0 mol dm^{-3} so, if students chose H_2SO_4 its concentration needs to be 0.5 mol dm^{-3}. Likewise for **E** it needed to be clear that the concentrations of Fe^{2+} and Fe^{3+} are both 1.0 mol dm^{-3}, which caused problems for some students who chose to suggest the use of $Fe_2(SO_4)_3$. For **D** it is clear that some students are using out of date concepts with references to 1 atm as standard pressure.

3.5 This was another question that proved harder than expected and that, again, revealed weaknesses for many students when it comes to writing a balanced equation.

3.6 The symmetry of the values in the results table was, presumably, a factor in ensuring that almost all students scored at least one mark here and it was pleasing to see that a majority of students could choose a suitable scale and plot the points. Some students still need reminding that a ‘suitable’ scale must be linear and that the plotted points occupy at least 50% of the available space along the axis.

3.7 Most students sensibly chose to use values from the results table to calculate the gradient, which reduced errors resulting from misreading their scales. The need for the gradient to be negative was a stumbling block for some. A significant number of students then, however, tried substituting values into the whole ‘y = mx + c’ expression and failed to realise that the gradient is equal to ($-4.3 \times 10^{-5}T$).

3.8 Most students seemed to rely exclusively on the use of an equation such as $E_{cell} = E_R - E_L$ (in this case giving $1.13 = 0.33 - E_{Zn}$, so $E_{Zn} = 0.33 - 1.13$), which caused problems for some when re-arranging.

Question 4

4.1 Most students correctly remembered this name.

4.2 A key phrase in this question was “explain how the structure of ethanal leads to the formation of two isomers”. This wording was unfortunately missed by many students who instead referred to the structure of the product and wrote about the chiral carbon. Those who recognised the need to refer to the planar carbonyl group sometimes made the mistake of referring to ethanal itself as planar – which is not true for the whole molecule. There are many different ways of drawing 3D representations, but the style shown in the mark scheme is recommended for clarity. Enantiomers should either be shown by drawing the second image as a mirror of the first, or by drawing the same orientation as the first but with two groups swapped round.

4.3 It was clear from the structures drawn in 04.2 that most students knew the structure of 2-hydroxypropanenitrile but, despite that, many here failed to recognise that this involved the dehydration of an alcohol to an alkene. Some students seemed to confuse the reaction with the elimination reaction that converts a halogenoalkane to an alkene.

4.4 Most students were able to draw this fragment of the polymer although there was some carelessness with the positioning of the bond to the CN group.

Question 5

5.1 This was another question that required a balanced equation to be produced and another question that was much less well answered than expected.

5.2 Most students knew to only include the concordant values in this average.

5.3 Another equation that over half of students were unable to construct, despite the familiarity of acidified manganate(VII) as an oxidising agent.

5.4 Many students reversed the correct colour change for this answer, while others failed to recognise the need to mention both colours when describing a change. ‘Purple’ was not allowed as the final colour because the question asked for the colour change at the endpoint and seeing ‘purple’ would indicate that the endpoint had been overshot.

5.5 Most students knew both these pieces of measuring apparatus.

5.6 As was the case last year, when a question about using a thermometer was posed, many students failed to recognise the need to double the apparatus uncertainty as two readings are being taken.

Section B

The mean percentage of marks scored on the multiple-choice questions was just over 60%, a very similar outcome to that seen in both 2017 and 2018.

Questions that proved to be substantially more accessible than the ‘average’ items included numbers 9 (around 80% correct), 10 (84%), 13 (85%), 29 (86%), 30 (88%) and 32 (83%).

Questions that were substantially more challenging than the ‘average’ items included numbers 18 (around 40% correct), 22 (34%) and 34 (40%).

Mark Ranges and Award of Grades

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