AQA
Questions matter

A-level
Chemistry

7405/3 Paper 3

Report on the Examination

7405
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General

As in previous series the most common reason for failing to gain marks was a lack of precision when showing the working for a calculation or when providing an explanation. There is a tendency for students to repeat the fact or idea they are being asked to explain rather than actually explaining it.

Relatively few students (about 20%) were able to access Level 3 in the Levels of Response question (05.1) – usually due to a failure to give a clear explanation of the origin of colour or to explain the use of colorimetry correctly.

Question 1

Part 01.1 was designed to be an easier start than it turned out to be as it was expected that this esterification would be relatively familiar to students. Many failed to show the organic product in a skeletal format.

In 01.2 over 50% of students achieved the mark but many answers were too vague. When a question asks for a reason in this sort of situation, something more specific than 'it is harmful' is needed in the answer.

01.3 Most students recognised this mechanism as addition-elimination.

01.4 Most students also realised that the phosphoric acid is a catalyst in this reaction.

01.5 seemed to cause more problems than expected, with only 20% of students earning this mark. The context is slightly unusual as it is perhaps more common to ask why reflux is needed for a reaction than to ask, as here, why it is not. A clear reference to the boiling points of the reagents being above 85 °C was needed.

In 01.6, there were significant weaknesses revealed in students' abilities to draw apparatus diagrams. They should realise that a cross-sectional line diagram is needed and, in particular, that a glass tube passing through a bung needs to be drawn clearly as open at both ends. When representing a Buchner funnel the filter paper must be drawn horizontal.

In 01.7, 75% of students correctly suggested at least one impurity.

01.8 This was the first question to require an extended answer on this paper and dealt with what should be a familiar scenario. 43% of students were able to score 4 or more marks. However, many answers were confused and lacked a sensible sequence. Students need to be clear about the distinction between residue and filtrate when describing filtration – especially as the first filtration step here retains the filtrate but the second retains the residue. It was hoped that all students would realise that a reference to recrystallisation indicates that the product is solid, but some tried to describe distillation or solvent extraction processes.

01.9 This question provided further evidence that some students thought that the aspirin was a liquid because 'boiling point' was often suggested as the physical property that is measured.

Question 2

This proved to be the hardest question on the paper; probably because of the unfamiliar context of some parts and the need to interpret information that was given in the questions.

02.1 Answers showed a weakness in understanding the reasons for a practical technique and an inability to work out the reasons from the context and the method described. Using a cotton wool plug instead of leaving the flask open is to avoid the risk of acid spray (which would affect the mass readings as well as being a safety issue), while using cotton wool instead of a bung is simply to allow the gas to escape – because the method depends on measuring mass loss.

02.2 was only answered correctly by 6% of students because most automatically referred to the concentration of the $CaCO_3$ being constant because it was in excess – but the concept of concentration does not apply to a solid in the way it does to a gas or solution. The hoped-for answer was that the surface area remains virtually constant (as this is the key property of a solid reactant that affects rate) but a reference to mass or amount being constant was also allowed.

02.3 also proved very tricky. This question depended on interpreting the data provided within the question and there were two possible routes to the answer.
The first route required students to recognise that m_t / mass of CO_2 produced in time t would represent the hydrochloric acid that had reacted up to that time, while m_{total} / total mass of CO_2 produced represents the total hydrochloric acid that reacts (which, as the calcium carbonate is in excess, is also a measure of the initial amount/concentration of the acid). The expression (m_{total} – m_t) is therefore proportional to ($[HCl]_{initial}$ – $[HCl]_t$) and thus represents the remaining concentration of hydrochloric acid.
Alternatively students could recognise that (m_{total} – m_t) corresponds to total CO_2 produced – CO_2 produced up to time t and therefore represents the mass of CO_2 yet to be produced which will, in turn, depend on the remaining hydrochloric acid.
Correct references to proportionality were not insisted upon and references to 'being equal to' or representing, etc, were accepted as were various references to volumes, masses and concentrations or amounts.
This was a question where many students failed to score as a result of them repeating the relationship they were asked to explain.

02.4 40% of students earned full marks for this question but some of the chosen scales made it tricky for students to plot their points correctly. Students should not be concerned about filling the whole grid as the requirement for a scale to be considered appropriate is for the plotted points to occupy more than 50% of the space available along each side of the grid. It is best to stick to values such as 2, 5, 10 units for each large square where possible. It is also not always necessary to include 0,0 on a graph scale but, in this case, many students recognised that it was a valid point as the rate would be zero if the acid concentration is zero.

In 02.5, most students recognised that the line being straight was relevant to the answer, but many failed to mention that it passes through the origin.

In 02.6 a majority of students were able to suggest one suitable variable but only 16% scored both marks. In many cases unsuitable suggestions such as a disappearing cross method or a colour change were suggested rather than variables relevant to this specific context.

Question 3

Nearly 90% of students gained the mark for 03.1.

03.2 was another example of a slightly unusual context for this question and students needed to recognise that the units of *k* (s^{-1}) were the key to identifying that the reaction is first order.

03.3 was another graph question; the scales being provided made it more accessible though there was still some misreading of the scales.

In 03.4 students needed to recognise that the Arrhenius equation given in the question is of the form y = mx + c, so a plot of ln *k* vs 1/T will give a straight line of gradient $-E_a/R$. Calculating the gradient therefore leads to a value for E_a. Some students tried to substitute values into the whole equation but failed to realise that the y-axis intercept was not at 0 on the x-axis so the value of lnk at that intercept would not be equal to ln A.

03.5 tested the ability to apply information from the start of the question where the equation for the thermal decomposition of but-3-en-1-ol was given and to apply it to a different compound. Many students failed to respond to the need for a carbonyl as one of the products and suggested alcohols or acids instead.

Question 4

In 04.1 over 80% of students were able to give the correct definition of 'weak' in the context of an acid.

04.2 was a question where a lack of clarity in explanatory answers meant that many students failed to score. Just suggesting that the dropwise addition is to help find (or avoid missing) the equivalence point is not enough. The graph provided gives the underlying reason which is the rapid pH change for very little change in the volume of NaOH at the equivalence point.

In 04.3, 80% of students were able to score one or more marks but relatively few produced a complete expression and an explanation. Some students lost the mark for the expression by confusing the situation with the dissociation of a weak acid and showing K_a as equal to $[H^+]^2$ / $[CH_3COOH]$. Students need to remember that the approximation of $[H^+] = [A^-]$ only applies when a weak acid dissociates in aqueous solution. In a buffer, the concentrations of H^+ and A^- are not equal.

In 04.4 students needed to use the information provided, that pH = pK_a when half the propanoic acid has reacted, and find the pH at this point from the graph so that K_a could be calculated.

In 04.5 students often failed to give a full explanation and simply offered the idea that a buffer resists changes in pH. The use of the command word 'explain' indicates that more detail is needed in an answer. A second factor that prevented marks being earned were vague references to 'the equilibrium'. For example, a student's answer such as 'OH^- reacts with H^+ so the equilibrium moves to the right' would only score one mark as it is not clear which equilibrium is being referred to. An ideal answer would show the relevant equilibrium as $CH_3CH_2COOH \rightleftharpoons CH_3CH_2COO^- + H^+$, then refer to the added OH^- reacting with H^+ which, in turn means that the equilibrium (shown) moves to the right to compensate for the change and keep $[H^+]$ approximately constant.

04.6 A lack of clarity in the explanations offered again hindered things in this question although a majority of students scored one or more marks. The key for methyl orange is to recognise that its pH range (the range of pH over which it changes colour) does not match the rapid pH change on the titration curve, whereas for Universal Indicator, the problem is that there are many colour changes as the pH changes.

Question 5

05.1 was the Levels of Response question and there was a significant improvement in performance with nearly 20% of Students able to access Level 3 and score 5 or 6 marks. The main reason for an inability to access Level 3 was a lack of clarity in the description of the origin of colour in transition metal complexes. Many students failed to be specific about the light absorbed being in the visible region of the spectrum and the idea of d-d splitting was poorly explained in many cases. Misuse of terms such as orbital, subshell and shell contributed to a lack of clarity. The key ideas should be that the ligand approach causes a split in energy of the orbitals in the 3d subshell and that electrons in the d subshell can then absorb some wavelengths of visible light and become excited into the higher energy d orbitals. It is the remaining wavelengths of light that give the colour seen

05.2 60% of students scored two or more marks for this question with the most common error being the mis-conversion of nm into m. Some students read off the absorbance at the peak of the curve instead of the wavelength.

Section B – Multiple Choice

Some students need to pay more careful attention to the instructions given at the start of Section B about how to complete the answers by shading in the lozenge, crossing out an incorrect answer and then circling a crossed-out answer if it is then decided to be correct.

There were again quite a few instances of crossed out and circled answers alongside shaded lozenges – which has to be treated as two answers and so marked incorrect.

Multiple-choice items that proved to be very accessible (answered correctly by at least 75% of students) were B8, B16, B23, B24, B29, B33 and B35.

The most challenging items (answered correctly by fewer than 45% of students) were B7, B11, B28 and B34.

Mark Ranges and Award of Grades

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