AQA

A-LEVEL
CHEMISTRY

7405/3 Paper 3
Report on the Examination

7405/3
June 2023

Version: 1.0

General

As in previous series, the most common reasons for the failure to gain marks were lack of precision (especially when describing the steps in a calculation) and lack of clear application of chemical terminology. In particular, questions 01.5 and 06.1 caused problems in this regard. Relatively few students were able to access Level 3 in the Levels of Response question – usually due to a failure to properly describe a reason for effervescence with L but not with M. Students are encouraged to be as organised as possible when answering the Level of Response question and, although it is not really appropriate to layout the answer as a list, students are encouraged to think about aiming to make a sequence of clear, precise, linked points to put across their ideas with the aim of 'ticking off' as much of the indicative content as possible.

Question 1

Question 01.1 provided a reasonably straightforward start, with 67% of students correctly referring to 'catalyst'. A wide variety of incorrect answers was also seen, however, including oxidising agent and reducing agent. 'Proton donor' was not allowed because, although the mode of catalytic action does involve proton donation, the proton is accepted back in a later stage of the mechanism.

In 01.2, the first sentence of the stem gave a clue to the answer by stating that the reaction mixture is flammable and 86% of students responded to this clue by suggesting an answer such as 'water bath' or 'electric heater'. Note that a positive answer is needed so 'not with a Bunsen burner' did not score.

01.3 The mark scheme had an additional possible answer added because the diagram printed had a gap between the neck of the flask and the condenser. Reference to this gap and the possibility of vapour escaping was allowed, in addition to the expected answers referring to the bung causing pressure build-up or the incorrect direction of flow of water causing inefficient condensing. 45% of students obtained full marks here. Some students referred to a mistake being the absence of clamps – but the second sentence of the stem stated that it should be assumed that the apparatus is clamped correctly! Some students also got confused between reflux and distillation and suggested incorrectly that the condenser should be horizontal rather than vertical to avoid the vapour falling back into the reaction flask.

01.4 was a question where a lack of precision in answers meant that only 44% of students scored full marks. A clear reference to the fact that the sodium carbonate was added to neutralise <u>acid</u> was needed, together with recognition that this reaction produces carbon dioxide gas.

Answers to 01.5 also often lacked clarity and precision (such that only 24% of students scored both marks), with many students thinking that a difference in density alone accounts for the formation of two layers. The key factor is that the organic and aqueous materials are immiscible. The fact that the ethyl ethanoate forms the upper layer is then explained in terms that it is less dense (NOT lighter) than the aqueous layer.

In 01.6, 64% of students correctly recognised that the anhydrous calcium chloride is added as a drying agent although a significant minority referred to 'dehydration' which is not an acceptable answer due to the alternate meanings of that term in Chemistry.

In 01.7, nearly 90% of students scored 3 or more marks, with 55% scoring 5/5. Some answers gave the impression that the phrase 'limiting reagent' is less familiar to students than the idea of 'excess', but most were able to complete the first part of the calculation. The biggest source of error in the second stage related to various incorrect methods of calculating the 'theoretical yield' including adding together the masses or amounts of starting materials.

72% of students were able to correctly answer 01.8.

Question 2

Most of question 2 required students to be familiar with the dehydration of alcohols to form alkenes and therefore with the idea that the reaction involves the loss of OH from one C atom and the loss of an H from an adjacent C atom. Familiarity with the concept of isomerism was also required.

In 02.1, a displayed formula for pentan-1-ol was required (but only 36% of students correctly gave this answer) and the commonest reasons for the mark not being awarded were that the OH group was not displayed or that pentan-3-ol was suggested.

02.2 was answered better and it was pleasing to see an increased facility with which students were able to represent structures using skeletal formulae – but note that, in this case, the OH group must NOT be displayed.

Despite students not being very familiar with ethers, a majority of students were able to score in question 02.3.

02.4 proved one of the trickier questions on the paper with only 16% of students scoring here. The commonest error was to offer a tertiary alcohol as the answer – this suggested confusion about which alcohols cannot be oxidised rather than which cannot be dehydrated.

50% of students scored 3 marks in 02.5 and students are again reminded of the importance of being precise when drawing curly arrows in terms of where they start and where they finish. A curly arrow in any mechanism must always start either from the line representing a covalent bond or from a lone pair drawn on an atom. In this case, both arrows should have started from an existing bond in order to represent the breaking of that bond.

02.6 was a test of the understanding that dehydration involves the loss of the OH along with a H atom from an adjacent carbon. Only 30% of students could give the correct structure.

Question 3

Many students only scored 1 mark for 03.1, either due to just drawing NH_2 as an addition to the partial structure given or to drawing Phe correctly but with a COOH terminal group instead of the $CONH_2$ described in the question.

03.2 required students to deduce the structure of proline by working out what would remain from hydrolysing the peptide groups either side of proline in the partial structure given. 27% of students were able to do this. The commonest error was, as expected, to show an NH_2 group instead of NH.

In 03.3, the need for reflux with 6 mol dm^{-3} HCl is not well known by students – but nor is it specified in the specification. Therefore a wide variety of more generic answers related to the hydrolysis of amide links was also allowed, such that 80% of students were able to score 1 or 2 marks.

In 03.4, the key idea of this sort of chromatography (which is the need for the atmosphere in the tank to be saturated with vapour of the mobile phase) is clearly not well known by students, although it was pleasing to see a few such references. Again, various other valid suggestions were allowed as alternatives. Many students got confused between TLC and paper chromatography and were therefore led into talking about the need to support the paper so that it stood up in the beaker.

03.5 was a direct test of a statement in the specification, which refers to there being a balance between solubility in the mobile phase and retention on the stationary phase. Many answers were incorrect because they only referred to solubility in the mobile phase.

03.6 was quite well answered although some students suggested the use of UV – but this is not appropriate as something that is sprayed onto the TLC plate as described in the question.

78% of students were able to correctly calculate the R_f value in 03.7.

Question 4

As last year, only about 10% of students were able to access level 3 and score 5 or 6 marks. In this case, the most common omissions from the indicative content were 2b and 2c which related to the explanation of the reason for effervescence with L but not with M when carbonate was added. Many students thought that it was enough to simply say that CO_2 is produced with L but not M and did not go on to discuss the reasons for this in terms of the greater acidity of Fe^{3+}(aq) compared with Fe^{2+}(aq).

Many students did, however, recognise the important distinction that the 3+ ion with carbonate produces iron(III) hydroxide but the 2+ ion with carbonate forms iron(II) carbonate.
The quality of equations varied and there were sometimes contradictions between a statement that, for example, a reaction produces a precipitate of $Fe(H_2O)_4(OH)_2$ but then an equation showing the formation of $Fe(H_2O)_4(NH_3)_2$. Hydroxide ions were also often seen as a reactant in the reaction equations for Fe^{2+} and Fe^{3+} with ammonia.

It was unexpected to discover that a significant minority of students did not recognise the tests for ions that were included in the question – especially as some of these tests are first encountered at GCSE.

Question 5

05.1 was reasonably well answered by most students, although there was some confusion about the mass of water to use in the calculation with some using 397 g instead of 103 g.

In 05.2, there was significant evidence of confusion amongst many students about how to use the terminology needed. The question also specifically asked for shapes to be referred to in the answer but many students ignored this, which effectively meant that they could only score a maximum of two marks. A lot of answers gave the impression that students' thinking is somehow 'reversed' in relation to these concepts, with many answers seeming to imply that polarity in a molecule is DUE to its ability to form hydrogen bonds.

There was no need here to refer to intermolecular forces at all (that was required for 5.3). This question was also a prime example of the need for greater precision in the language used for an explanation – many students referred to differences in electronegativity without explicitly stating which atoms the difference was between or which way round the difference was (ie. which atom had the greater electronegativity).

Electronegativity was also often associated with a group of atoms or even a whole molecule rather than as a property of each individual atom. A good answer needed to refer to the fact that O and N are both more electronegative than C and/or H but that O is more electronegative than N. The shapes of all three molecules then needed to be identified (2 bent and one pyramidal) together with a reference to the fact that they are all asymmetrical.

Students need to remember that, for a molecule to have a dipole moment (ie for it to be polar) there is the need both for polar bonds to be present and for the molecule to be asymmetrical (eg the C=O bonds in CO_2 are polar as O is more electronegative than C, but the molecule overall is not polar due to its symmetrical, linear shape).

05.3 saw further confusion with the use of correct terminology and too many answers used phrases such as 'the hydrogen bonds between oxygen and hydrogen' – there is a real danger here of implying that it is a covalent bond that is being referred to (ie O-H) rather than an intermolecular force (ie δ-O-----Hδ+). What was hoped for here was the recognition that the most significant intermolecular forces in both ethylamine and ethanol are hydrogen bonds (with those in ethanol being stronger), while CH_3OCH_3 cannot form hydrogen bonds. The permanent dipole-permanent dipole forces are weaker than hydrogen bonds.

Question 6

In 06.1, the most common reason for a lost mark was a lack of clarity in explaining that 0.005 mol was the required amount of $Ca(OH)_2$ needed to react with the 0.01 mol of HCl. M2 was not awarded just for seeing 0.01/2 unless it was clear why this was done.

The application of a generous mark scheme in 06.2 meant that many students were able to access some marks despite quite significant misunderstanding as to what was required. Many failed to realise that the concentration of $Ca(OH)_2$ in the saturated solution could be found directly from the solubility data given.

Section B – Multiple Choice Questions

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.

Overall, Section B proved to be rather accessible, with a mean score of 19.3 out of 30.

Questions that were particularly accessible, with success rates of at least 80%, were 6, 8, 11, 14, 24, 28 and 34.

The trickiest questions, where 40% or fewer students gave the correct response, were 13 and 31.

Mark Ranges and Award of Grades

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