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Examiners' Report
Principal Examiner Feedback

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In Chemistry (WCH13) Paper 01
Unit 3: Practical Skills in Chemistry I

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Introduction

A significant proportion of students seemed inadequately prepared for this examination, demonstrating only a basic knowledge of the specification content and a limited experience of practical equipment and techniques. Conversely, some students were able to apply their knowledge with impressive accuracy and success to questions in both familiar and unfamiliar contexts.

Question 1

The large majority of students knew that a white precipitate would form in (a)(i), though some did not score the mark for inclusion of an additional incorrect observation, such as fumes, smoke or effervescence. The test for the production of ammonia gas was well known in (a)(ii) but many students did not give the test reagent, with even more omitting that the solution should be warmed, which is necessary and demonstrates the importance of students having practical experience of performing these tests in the laboratory. Some students confused HCl as a test reagent for ammonia gas with NaOH as the test reagent for ammonium ions. In part (b), most students seemed unfamiliar with the decrease in temperature associated with an endothermic process, again indicating a lack of practical experience. Many students confused the physical process of dissolving for a chemical process in (b)(i), giving insufficient reasons for stirring such as to ensure complete reaction; a greater proportion were able to communicate the need to ensure a uniform temperature in the solution. Only a small number of students knew how to use the data correctly in (b)(ii), with many attempting to intersect the cooling and warming regions rather than extrapolating back to zero time. The large majority of students demonstrated a misunderstanding in (b)(iii), treating the dissolving process as exothermic and incorrectly referring to heat loss to the surroundings as opposed to heat being transferred to the solution **from** the surroundings. Many students scored only one mark for this question, simply stating that polystyrene is a better insulator than glass. In (c)(i), many students recognised that the assumptions related to mass and specific heat capacity but did not receive credit for the redundant reference to water instead of the solution. Many general references to heat loss were seen, indicating a failure to appreciate the context of the question, which was about assumptions made in the calculation (and not about its result). The majority of students had some success in (c)(ii), even when they did not entirely understand what they were attempting to calculate. A common error was to apply the percentage uncertainty to the data book value instead of the experimental result. Careless rounding of the final answer was seen on numerous occasions.

Question 2

Although the combustion analysis may have been unfamiliar to the students, sufficient information was provided in the question. In (a)(i), many students thought that the mass of oxygen should be measured, failing to recognise that this was an excess reagent and without giving any practical consideration as to how this would be done; the mass of X also proving a distraction. No credit was given for reference to volumes / amounts instead of masses. Many general responses were given in (a)(ii) with much reference to air being a mixture of gases and/or unwanted side reactions. A surprising number of students thought that air contains hydrogen gas. Many students recognised that air might result in incomplete combustion. The empirical formula calculation in (a)(iii) was handled well by many, though failing to account for the residual mass of oxygen was a common error, indicating careless processing of the information provided at the start of the question. Many students did not score full marks as they rounded the mols of carbon from 1.5 to 2, failing to carefully consider the whole number ratios of the atoms of each element. Most students recognised phosphorus(V) chloride as the test reagent for the hydroxyl group in (b) but many did not score the mark through failure to consider the possibility of both carboxylic acid and alcohol functional groups. In (c), a significant number of students did not give sufficient thought to the information provided and, focusing on key words in the question, drew reflux apparatus or a separating funnel. Of those who did attempt to draw a distillation apparatus, common mistakes included drawing a one-piece apparatus without any joints between the separate pieces of glassware; having a sealed collection vessel; having a gap before the condenser where vapours would escape; the omission of a heat source. Many drawings of the correct apparatus were of a poor quality, indicating that more practice is needed. The majority of students understood how the infrared spectrum in (d) indicated the presence of a carboxylic acid functional group though a common slip was to omit the individual **bonds** responsible for each absorption. Some students referred to only one absorption peak and a minority incorrectly referred to the peaks as transmittance peaks. In (e)(i), most students showed that the relative molecular mass of $C_3H_4O_3$ is 88 though many did not make a clear reference to the molecular ion peak (or the peak with the highest *m / z* value). Most students included a positive charge on the fragment ion in (e)(ii) but a significant number did not read the question carefully, giving a molecular formula instead of a structure. Some students deduced at least one correct structure in (f) although the majority failed to use the information from earlier in the question and link the compounds by oxidation. Some did not read the rubric carefully, interpreting one **type** of functional group as just one functional group. Other careless mistakes, such as structures containing OH–C connectivity or tri/pentavalent carbons were not uncommon.

Question 3

A minority of students gave a full equation in (a)(i). Common mistakes in ionic equations included uncancelled spectator ions; incorrect charges on the barium and sulfate ions; and the omission of state symbols. A significant number of students gave an ionic equation for the formation of sodium chloride. Following on from the previous question, many students recognised that sulfate ions were added to remove barium ions but very few appreciated that this was to prevent them from reacting with chromate(VI) ions. Although this is not something the students were expected to know, the procedure hinted that the end-point of the titration occurred on the formation of silver chromate(VI) so they might have reasoned that barium ions could interfere with this. Some students did not appear to consider the context of the question at all, simply stating that sodium sulfate is a drying agent. Only the most able students were able to make the connection between precipitation and solubility in (b), with most repeating the question or attempting to compare the reactivity of chloride and chromate(VI) ions. The large majority of students were able to calculate all three titres in (c)(i) as well as the mean from the concordant results. Some used only two of the three concordant results to calculate the mean and students should also be reminded to record their titres to two decimal places. The students tackled the unfamiliar titration in (c)(ii) with varying degrees of success with around one-fifth scoring full marks and some concise and clearly presented responses seen. Common errors included failing to consider the mol ratio of chloride to barium ions and/or the scaling factor of 10.0 cm^3 to 250.0 cm^3. Students are advised to use simple flow diagrams or storyboards to plan their route through unfamiliar and unstructured titration calculations. They are also encouraged to revisit the data and their working when they arrive at an impossible answer (eg, x = 158 in this question).

Question 4

Most students understood the purpose of the calcium chloride in (a)(i), though relatively few scored the second mark as they missed the significance of the **explain** command. Only a small proportion of the students appreciated that powder would prevent gas from freely flowing through the apparatus in (a)(ii), with most incorrectly referring to surface area and rate of reaction. Students must consider the context of a question: the word “granules” distracted some to discuss the purpose of anti-bumping granules in this case. The more familiar question in (b)(i) was generally well answered although a common mistake was to describe chlorine as corrosive or even flammable. Students should be discouraged from using the term “chamber” for (fume) cupboard. Many students incorrectly thought that the acid was added drop by drop in (b)(ii) so as not to break the apparatus or to prevent an explosion. Other general responses relating to the exothermicity / completeness of reaction did not receive credit. Again, the context of the question was missed by some students, with the term “drop by drop” causing some to discuss titrations. A common misconception in (c) was that the apparatus was being left to cool (even though they would then have been heated in the next step of the procedure). Many students got close to the correct answer in realising that the chlorine had to reach the aluminium but missed the point that the apparatus needed to be empty of air. A common incorrect response to (d) was to heat to constant mass, where it was misunderstood that the mass of aluminium chloride in the receiver bottle could not be monitored. Other general responses referring to no more product being formed / all of the reactants being used up did not receive credit. General responses were again a feature in the final part of the question, with many students referring to the absorption of just toxic gases or acid. Students should be reminded of the difference between hydrochloric acid and hydrogen chloride. Some students did not consider the specifics of the chemistry, stating that the purpose of the potassium hydroxide was to absorb carbon dioxide.

Summary

In order to improve their performance, students should

- conduct practical work to gain knowledge and experience of practical procedures, equipment and techniques
- not give general responses to practical questions set in a specific context
- consider all information provided, highlighting key instructions and data
- practise drawing distillation apparatus, following its use
- not repeat information provided in the question
- read the question carefully, consider its context, and make sure they are answering the question asked
- use simple flow diagrams/storyboards to plan their response to unstructured and unfamiliar titration calculations
- consider if their answers to multistep calculations make sense and check their working

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