

Examiners' Report

Summer 2013

GCE Chemistry (6CH02) Paper 01R
Application of Core Principles of
Chemistry

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Introduction

The paper was accessible to all candidates. It was rare to see a question which was not attempted, and there was no evidence of any lack of time. This unit does not have many mathematical topics, and the few calculation questions on the paper were done well.

Candidates showed limited knowledge of practical techniques, and questions in which they had to describe experimental techniques were very discriminating. The most demanding questions were those which required explanations to be given. Candidates had clearly learnt phrases from text books, but often quoted them without putting them in meaningful context.

Question 21

The calculations in parts (a)(i)-(iv) were usually well done. Numbers should not be rounded until the final stage of a calculation, and this was usually done correctly. Candidates who kept the numbers in standard form e.g. 1.41×10^{-3} were less likely to make rounding errors than candidates who expressed this answer as 0.00141, as this value was sometimes rounded to three decimal places which give insufficient accuracy.

Errors occurred most often in (a)(iv) where candidates calculated the relative molecular mass of calcium hydroxide incorrectly, or divided the number of moles by M_r instead of multiplying.

The method by which the accuracy of a pipette could be checked produced many answers in which the pipette was weighed empty, and again when filled with water. There were no mentions of perhaps using (weighed) plugs to prevent the water from leaking away!

However, most did what was expected by transferring water from a pipette to a pre-weighed beaker. Some suggested comparing the mass of water in the pipette with the mass from another pipette, but this is no use without a method of checking that the reference pipette is not faulty. Others used a 25 cm^3 pipette twice to measure 50 cm^3 , which introduces error.

The reactions of calcium and its compounds in (b) were generally well known. A common error in **A** was to give the condition as heating in air or oxygen. This implies that an oxidation reaction is occurring, rather than a decomposition, and was not allowed. The formulae in **B** and **C** were sometimes given incorrectly, and hydrogen instead of water suggested as a product in **B**.

The question in (c) asked for an observation, and most candidates suggested effervescence, bubbling or fizzing. The mark was not given for simply naming the gas produced or giving a test for it.

In (d) candidates saw the words "thermal stability of carbonates" and nearly all discussed the relative polarising abilities of magnesium and calcium ions,

and why magnesium carbonate decomposes more readily than calcium carbonate. Unfortunately for these candidates the question was about the lattice energies of the carbonates, not the comparative ease of thermal decomposition. Most candidates gained the first mark for saying that the calcium ion was larger than the magnesium ion. Answers referring to atoms, or just saying that "calcium is larger than magnesium" were not given this mark.

For the second mark there had to be an explanation based on the relative attraction of the metal ion for the carbonate ion. Candidates who said that there was more shielding in the calcium ion were often thinking about the attraction of the calcium nucleus for its own electrons, rather than the attraction for the carbonate ion. This question illustrates the importance of reading the paper carefully, and not giving a routine answer to a question which has been seen in a previous paper.

The final part of this question began by asking for two flame colours. Magnesium ions do not give a flame colour, but the bright white light which is seen when magnesium metal is burnt was regularly suggested. In the first electronic transition, electrons are excited to a higher energy level, and this transition was sometimes missed out. When the electrons return to the ground state energy is emitted. This produces the flame colour, and the energy emission had to be mentioned to score the final mark.

Question 22

The equation required in (a) was for the complete reaction between sodium and ethane-1,2-diol, so if the substitution of only one sodium atom for an OH group was given, the answer could score only one of the two possible marks. An equation based on complete molecular formulae i.e. using $C_2H_4O_2H_2$ and $C_2H_4O_2Na_2$ was allowed one mark if balancing was correct and hydrogen production was shown.

Generally, molecular formulae should not be used to illustrate the products of organic reactions as it is better to show how functional groups are changing.

In (b) many candidates failed to read the question, which asked how the apparatus would be changed to achieve the oxidation of ethanol to ethanoic acid. Most answers simply mentioned the need to 'heat under reflux' without referring to the actual apparatus change. Several drew a diagram of the reflux apparatus, which was acceptable, but those who described having a vertical condenser often omitted the need to remove the thermometer, or to leave the top of the condenser open. Some answers referred to the reagents involved, suggesting the use of a more concentrated solution of potassium dichromate(VI). This is not a change of apparatus so did not score.

The skeletal formula required in (c) sometimes showed ethane-1,2-diol instead of ethanoic acid. Candidates should be advised to take care in showing bonds to OH groups. The bond should go from the carbon to the

oxygen atom, and bonds connected to the hydrogen atom were not given credit.

Answers to (d) sometimes lost marks due to careless use of English. The statement that "phosphorus(V) chloride reacts with OH groups" is true, but does not answer the question unless it is clear that there are hydroxyl groups in both ethane-1,2-diol and ethanoic acid. Hydroxide groups were not allowed here. The alternative answer to the question was to say that steamy fumes would be produced with both organic compounds.

Completing the spectrum in (e) was a novel type of question, and was attempted quite well. Precision with regard to the correct wavenumbers was often lacking, and many candidates did not appreciate the significance of "strong" and "weak" in the descriptions of the absorptions. The peaks at 2900-2700 cm^{-1} were often shown going down to the same level as the peak at 1750-1700 cm^{-1} .

Only a few candidates erroneously drew an absorption peak for the O-H bond. However, in (e)(ii) many candidates stated that the peak at 3750-3200 cm^{-1} was due to an O-H group, and did not identify the substance which caused the peak, namely unreacted ethanol.

There are many possible fragments which appear in a mass spectrum when ethanoic acid is produced. The formula had to be shown including its positive charge.

Some candidates did not appreciate that completing the mechanism in (f)(i) involved drawing curly arrows to show electron pair movements. They simply showed an intermediate or a transition state and the products. The mark scheme required two curly arrows, showing attack by OH^- and loss of Br^- , and the products also had to be shown, but the transition state was not essential. It was common to forget to include the bromide ion in the products. Either an SN_1 or SN_2 mechanism was allowed if correctly drawn.

Candidates who drew an SN_2 mechanism and included a transition state often omitted the curly arrow showing loss of Br. The attempts at SN_1 were more likely to show both curly arrows, but often included errors when showing charges. The reaction is a nucleophilic substitution, and the abbreviation SN was only allowed one of the two marks.

The solubility of silver chloride in concentrated ammonia was usually given correctly, but giving a suitable test to confirm the identity of silver bromide was a discriminating question. Many candidates knew how to use dilute aqueous ammonia to distinguish the two halides. Other tests which were suggested were often unsuitable. A substitution reaction with chlorine would only succeed with a solution of a halide, and "leaving in sunlight" would not give a clear distinction. Use of concentrated sulfuric acid on the solid is a possibility, but candidates who suggested doing this on the ammonia solution, or on an "aqueous solution of silver bromide" were not given the mark.

Question 23

The equation for the decomposition of hydrogen peroxide in (a) was usually given correctly.

The dot and cross diagram of an oxygen molecule was also well done. The dot and cross diagram for hydrogen peroxide caused more difficulty, as the information that each oxygen atom is covalently bonded to one hydrogen atom was not used to deduce how the atoms were linked. Structures with rings and O-H-H-O bonds were shown and obviously did not score.

The most common suggestion in (d) for the bond angle in hydrogen peroxide was 104.5° . In reality it is slightly less than this, but candidates usually knew the bond angle in water and were awarded the mark for this value. Many went on to explain the greater repulsion of lone pair-lone pair electron pairs as compared with bonded pair-bonded electron pairs. The phrase "maximum separation and minimum repulsion" occurred repeatedly, often without being in any context. If correct words or phrases are used without being put together in a meaningful manner, they will not be given marks. Answers must be in the correct context.

An advantage of using glucose to fuel a nanorocket is that it is renewable, and this answer was often given in (e). There were many mentions of hydrogen peroxide being "harmful", but this word was considered to be too vague. Candidates who said that the carbon dioxide produced from glucose would contribute to global warming had not read the introduction to the question, where the size of a nanorocket was indicated. In a question like this, both marks will only be given if the advantage and disadvantage are distinctly different. For example it is not enough to say that glucose is renewable, but hydrogen peroxide is non-renewable.

The explanations of the relatively high boiling point of hydrogen peroxide in (f) were often poorly expressed. Many candidates said that there were hydrogen bonds "in hydrogen peroxide". They went on to discuss the relative electronegativities or partial charges associated with hydrogen and oxygen atoms, making it impossible for examiners to decide whether they were discussing bonds between molecules, or the O-H covalent bonds. Some candidates said that the intermolecular forces were hydrogen bonds and London forces, but then did not clarify that the hydrogen bonds were the major contributor to the strength of the intermolecular attraction. For the second mark it had to be clear that the presence of hydrogen bonds meant that more energy was needed to separate the molecules.

There were two possible methods in (d) to test whether a liquid is polar. One involved deflecting a stream of liquid with a charged rod. It was not enough just to say that a charged rod was brought near the liquid under test unless it was clear that there was a flow of liquid. Some candidates wrongly thought that magnets, rather than electrically charged objects could be used. The alternative method was to test miscibility with another liquid known to be polar or non-polar. Here candidates often failed to state whether the liquids they were using, usually water or hexane, were polar or

non-polar. The use of infrared radiation was not allowed, as this only indicates the presence of polar bonds.

Many marks were lost in (f) for poor drawing and labelling of the Maxwell-Boltzmann distributions. Both axes had to be labelled correctly. Often candidates put a label below the horizontal axis saying "Activation energy" but did not make clear whether it referred to the axis or the vertical line.

More serious errors were axis labels saying rate, reaction path or temperature. The two curves had to start at the origin and should have approached the horizontal axis without crossing it. They should not have finished on a plateau that was significantly above the horizontal axis. The peak of the curve at 37°C should have been lower and clearly to the right of the peak for laboratory temperature. However, the final mark for knowing that a greater proportion of particles have sufficient energy to react at the higher temperature was well known.

The wording to the answers to (i) was identical for many candidates, and suggested that they had memorised the definition of a catalyst.

In (j) marks were lost where candidates described electrons as "free" rather than delocalised. A mention of "delocalised ions" was sometimes seen. Candidates should be careful about statements such as "nanotubes consist of delocalised electrons". This is another example of a relevant phrase made meaningless by being used incorrectly.

In (k) candidates had to suggest why use of nanoparticles in cosmetic products could pose a health hazard, and this required the idea that they could cause a problem if they were absorbed, or if there was long term use. Many answers suggested that they could be absorbed through the skin but then did not suggest why this might be hazardous. Others described possible consequences without indicating how nanoparticles could get in to the body to cause them.

Summary

Many good scripts were seen for this paper. However, there were several questions where candidates did not read the question carefully, and though they made correct statements they did not answer the question which was asked.

The weakest area was in answering the questions on organic chemistry. When an organic mechanism is required, the electron movements should be shown with curly arrows. It is usually best to show the structural formulae of organic compounds in equations, as they are helpful in showing the changes in the functional groups.

It is also important to understand the reasons for the technique chosen to carry out an organic reaction. Candidates might benefit from actually trying to carry out their suggestions for practical questions such as 21(a)(vi) and 22b. If they saw for themselves the water running out of the full pipette that they had put on the balance, then they should immediately see how impractical the suggestion is, and this would reinforce their understanding of what they are doing. Likewise, if they physically try to rearrange apparatus from reflux to distillation as they described, they would more readily appreciate the need to remove the thermometer in order to leave the condenser open.

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