# Examiners' Report
# Principal Examiner Feedback

## Summer 2024

Pearson Edexcel GCE
In Chemistry (9CH0)
Paper 03: General and Practical Principles in Chemistry

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## General Comment

It was clear that there were some very well-prepared candidates who were able to give a clear demonstration of their practical chemical knowledge and understanding. However, it was also evident that there were many candidates who appeared not to be fully prepared for the demands of a paper designed for candidates at the end of their A Level programme. The lack of precision and clarity in a large number of responses resulted in less marks being awarded than obviously was hoped for. Candidates would certainly benefit from more practice and answering the question as set.

## Question 1

Recall of the definition of relative isotopic mass in part (a) was intended to be a gentle start to the exam paper and the majority of candidates found it accessible. However there was considerable confusion seen with many relative atomic mass definitions given instead. Candidates are reminded that reference to an "atom" of the isotope or the standard of carbon-12 is essential with such definitions. It was unclear why but a small minority of candidates quoted carbon-13 as their reference standard and so did not score M2.

It was good to see candidates working out the number of molecular ion peaks that would be made from the three hydrogen isotopes. However only the more able spotted that two combinations of isotopes would have the same $m / z$ value and so result in a total number of five peaks and not six. A wide range of suggestions were seen, even up to eleven.

## Question 2

In part (a) it was pleasing to see a large number of candidates clearly and succintly explained how London forces arise. Two common errors were stating that the initial instantaneous dipole was induced, and omitting the reference to other/adjacent molecules for the induced dipole.

The majority of candidates in part (b) could correctly identified compound A as having the highest boiling temperature and were able to explain why. Occasionally some candidates failed to link the branching to the strength of London forces and so lost M1. Candidates are advised against using non-standard abbrevations, such as LDF presumably for London forces and SA for surface area. These may not gain credit.

It was good to see some well-reasoned responses to the deflection experiment in part (c). However an orderly and clear response was not always seen. Many had the tendency to state that a molecule was non-polar/polar without explaining why or only focussed on bond polarity and molecular shape for one of the molecules rather than all three. It was evident that some candidates misunderstood the labelling of the charged rod and referred to chloride ions in the chlorinated alkanes.

**Question 3**

A significant number of candidates got the right idea in part (a) of the small crystals going through the filter paper, while others gave vague comments about the crystals being filtered without stating what this meant. Unfortunately, answers referring to the dissolving of the small crystals were seen regularly. Also a notable number of responses referred to the crystals sticking to the filter paper but this would not lead to a lower mass since the filter paper was wieghed at the end.

In part (b) it was rare to see candidates specifically referring to the correct chemicals that could be rinsed and referred just to the solution instead. It was disappointing that so few attempting to explain the consequence if rinsing did not happen. In addition, some referred to the dissolving of "insoluble" impurities showing a fundamental misunderstanding.

The calculation in part (c) was competently done by most candidates and all three marks awarded. Candidates are reminded to remain in the answer space for each question. There was a large number of candidates who strayed outside of the designated area and this made it more difficult for examiners to mark.

The question of (d)(i) was another were the second mark needed to reason on the consequence of the action from the first mark. Many candidates correctly understood that some of the solution would be lost on the bench and gained M1 but few then reasoned that this would result in fewer moles of $M_2SO_4$ and that this would then lead to a higher relative formula mass. A small minority suggested that the glass rod would pick up impurities or such from the bench but then failed to go on and reason the effect of this.

Part (d)(ii) illustrates that sometimes an answer for one mark needs more than one facet. In order to gain the mark an answer needed to refer to the action of rinsing, the deionised/distilled water used for the rinsing and that the rinsing would be put back into the beaker. These are all simple parts but essential for the response to score the mark. Not surprisingly these were often not always stated.

The origin of a flame colour has been examined many times before and it was evident that most candidates knew the expressions required for part (e)(i). There were only a few occasions when a reference to transmission of light or light being reflected and these were penalised. At times the reference to heat energy being responsible for the excitation of electrons was missing.

It was pleasing to see so many correct answers scoring both marks for part (e)(ii) on the advantages and disadvantges of a flame test in identifying metal cations. These were not always clearly identified as such and so examiners had to use their judgement whether the response was 'for or against' the use of flame tests. Candidates may not always be so fortunate.

## Question 4

There were large numbers of correct answers to part (a)(i) either by the total entropy change 'route' or the Gibbs Free Energy change 'route'. Occasionally a mark was lost for giving incorrect units for the final answer, either including Kelvin for the Gibbs Free Energy change value or for omitting such for the total entropy change value. A small minority confused the two methods. There was also a small number of candidates that calculated a negative value for the entropy change of the system and use of this value would result in a final value that suggested the reaction was feasible instead of not so. This should have prompted candidates to revisit their initial calculation to determine their error. Alas this seemed to be rarely the case.

The vast majority of candidates found the calculation in part (a)(ii) very accessible but there were a sizeable number who missed the requirement in the question to firstly convert to degrees Celsius and secondly, to give the answer to two or three significant figures. The third mark was dependent on doing both of these two things.

Part (b) was another question on a familiar topic for candidates and this was evident in the many excellent answers covering all three necessary points. The marks which were lost tended to be more likely as a result of lack of precision than of understanding. For example, polarising the nitrate ion by the calcium ion means a distortion of the nitrate electron cloud. Use of the specialist term 'polarising' covers this. If a candidate chooses to describe this rather than use the specialist term then fine, but all aspects are required. It is not enough to just state that the calcium ion distorts the nitrate ion, there needs to be explicit reference to the electron cloud. Likewise, the effect of this polarisation is the weakening of the bonds within the nitrate. It is not the bond between the calcium ion and the nitrate ion which is weakened and this needed to be made clear. Also it is worth reminding candidates that charge density is not the same as electron density.

The balancing of the ionic equation in part (c)(i) was only achieved by the more able candidates. The suggestion to use oxidation numbers in the question was given to aid the candidates but this was not often heeded. Nevertheless, there were a reasonable number of candidates that scored the mark.

The simple test for ammonia in part (c)(ii) was well-known with only the occasional reverse colour change to red being stated.

## Question 5

This extended open response was answered very well with the vast majority of candidates scoring high marks. The most common indicative point missed was the comparison of the products of bromination. Frequently the name of the product of the bromination of cyclohexane was wrong, either losing the 'cyclo' or missing the 'di' before the bromo. Equations were accepted as means for gaining credit but oftentimes incorrect products such as hydrogen were given. Alternatively hydrogen bromide was missing as a product from the bromination of benzene.

Another common error was to state that heat was required for both reactions but cyclohexene will react at room temperature. It was insufficient to state that benzene requires a halogen carrier but cyclohexene does not.

It was also not usual to see a response which stated that benzene has a delocalised pi system but candidates must remember that this is a delocalised "electron" system and it is essential to mention this in this context.

There was also a small number of candidates that confused phenol with either cyclohexene or benzene and referred to a product with three bromine atoms.

Despite the question stem stating that details of reaction mechanisms were not required, it was not unusual to see considerable time spent on this matter and this was true of even those scoring high marks. Candidates would be better served if they stopped to think a while and plan out their answers in response to the key points raised in the question.

**Question 6**

The variety of methods for carrying out the molar calculation in part (a) meant that all three marks was frequently awarded.

The explanation of the NMR splitting pattern in part (b)(i) was generally done well with only a small minority referring to the adjacent hydrogen atoms rather than the hydrogen atoms bonded to the adjacent carbon atoms. Some answers referred to the fact the the adjcent atom was an oxygen rather than a carbon and this was acceptable. Candidates came up with a range of different labelling approches to part (b)(ii), most of these were acceptable. At times the central $CH_2$ group was though to be different to the other two such groups but this was rare. The splitting patterns and the relative peak areas of part (b)(iii) were usually correct but it was the chemical shift values which caused the most difficulty. The alkane H–C–C environment should have given a value from the Data Booklet of less than 2.0 ppm. Oftentimes a value was missing altogether which was disappointing given that it was the first requirement listed in the question. On other occasions a value of 2 or higher was suggested which did not score.

**Question 7**

The drawing of a reaction mechanism with curly arrows has improved over recent years and many responses scoring full marks were seen to part (a). It is possible that the use of skeletal formulae benefitted candidates because the inclusion or omission of the additional hydrogen on the carbocation intermediate was ignored. A small minority of candidates appeared to think that cyclohexene was aromatic and tried to draw an electrophilc substitution reaction mechanism.

The organic synthetic pathway required in part (b) was also an improvement on previous years. There were less instances of inappropriate reagent pairings such as the use of sodium hydroxide for Step 1 but quoted with sulfuric acid. This question well illustrates the need for candidates to check their answer after re-reading the question because marks were lost due to missing conditions and reaction types. Furthermore, some candidates quoted both the name and the chemical formula but if so then both must be correct to score the mark. Unfortunatley some candidates gave the wrong formula for potassium/sodium dichromate(VI). A reminder that there is often some leeway with the spelling of a chemical name such a too many 't's in potassium but there is no such leeway for a chemical formula.

It was good to see that the answers to part (c)(i) were all names as per the question rubric. It was surprising at times to see solid compounds rather than liquids suggested for the Grignard reagent solvent. In part (c)(ii) the vast majority of candidates knew that anhydrous calcium chloride is a drying agent but oftentimes incorrectly referred to the absoprtion of water from the reaction or from the solvent. The diagram of the apparatus on the facing page clearly shows 'Tube X' a long way away from the flask with the solvent at the top of the condenser and with an open top. It should have been clear to candidates that it was to prevent water vapour from getting into the apparatus. Nonetheless it was good to see that many candidates understood the need to keep the Grignard reagent away from water to avoid hydrolysis to the alkane. Likewise many candidates in part (c)(iii) knew that the corrrect water flow in the condenser from the bottom up means that it will avoid air bubbles and be filled with water for efficient condensation.

The colour of the precipitate in part (d)(i) was almost universally given correctly and the completion of the simplified mechanism in part (d)(ii) allowed candidates of all abilities to gain credit. It is pleasing to see that candidates seem to be getting better at drawing curly arrows for a novel organic mechanism.

The descriptions given for the recystallistion process in part (d)(iii) varied significantly. There were some excellent, logical descriptions with additional details of a 'hot filtration' to remove insoluble impurities which showed that these candidates were very well prepared. However there were many other responses which unfortunatley made little practical sense. For example, it was not unusual to see the response begin with the dissolving of the impure precipitate and then this being immediately filtered, washed and patted dry without there being any mention of cooling to form a purified precipitate. These responses were not given credit for statements that were impractical.

**Question 8**

In parts (a)(i) and (ii) many candidates thought that the issue was the indicator rather than the weak acid – weak base titration. Only the more able identified the true situation and gave appropriate suggestions. It was disappointing that even when some candidates extracted the correct pH range for phenolphthalein from the Data Booklet and quoted it as 8.2 – 10.0 they still wrote that it would change colour.

The mark allocation for part (a)(iii) should have highlighted that an in-depth answer or jutification was required for three marks. Large numbers of candidates simply wrote $K_a$ = $[H^+]$ or pH = p$K_a$ which gained one mark but no more. This provided another opportunity for the more able candidates to demonstrate their understanding and gain the additional available marks.

Parts (b) and (c) were multi-stage calculations which were often done absolutely correctly but if not, still gave candidates the opportunity to gain at least some credit. The most common error in part (c) was not realising that sulfuric acid is diprotic.

It is importan to remind candidates that with calculations, a logical layout, with clear labels for each step will definitely increase the chances of gaining marks.

## Question 9

In part (a)(i) the tendency for the less able candidates was to be too generic and to refer to the need for goggles, lab coats and to avoid touching hot equipment or concerns over flammability. Those candidates who did identify the fume cupboard as the necessary precaution, needed to state that sulfur dioxide is toxic or corrosive and not just harmful or an irritant.

Part (a)(ii) was the first of a number of questions which required the explanation of an effect and candidates must note that credit is not always given just for the effect since this can be a fifty-fifty. In this case, reference to an increased titre did not gian credit unless there was some link to the greater acidity of the mixture if the dissolved gases were not removed. Some candidates related the increased acidity to carbonic acid from carbon dioxide but from the outset of the question, sulfur dioxide is referred to and so it was essential for this to be referred to if both marks were to be awarded.

The calculation in part (a)(iii) was generally correctly done. Common errors included switching the volumes around and failure to convert from moles to grams per cubic decimetre.

Part (a)(iv) was a second question requiring an explanation of an effect, namely what the presence of an air bubble in a burette tip would do to the titre. The majority of responses did refer to the titre including the volume of the air bubble but those which simply stated that the titre would increase did not score.

Another molar calculation which was well-done in part (b)(i). It was pleasing to see that most candidates did not stop at just the calculation but related their value to the fact that it was below the permitted maximum of 200 mg $dm^{-3}$. Candidates appear to have learned that this is a vital part of their answer from previous such questions. One relatively common error was to use a combined volume of 55 $cm^3$ for the wine calculation but careful review of the procedure shows that a volume of 50 $cm^3$ of wine was used, the additional 5 $cm^3$ was sulfuric acid which should have been discounted.

The question in part (b)(ii) was aimed at the very best of candidates who could apply their knowledge to a rather novel situation. Few responses were seen where the production of carbon dioxide was identified as the key to the answer.

## Question 10

It was not unusual to see a response for part (a)(i) which correctly deduced that the crushed ice was used to quench or to stop the reaction but then to fail to explain the reason for doing this. It is a reminder to candidates to always seek an explanation for why procedural steps are taken. In this instance there needed to be time for the titration to be carried out without the concentrations changing. Whilst it is true that the reaction is technically slowed rather than stopped, it is important for candidates to understand the principle.

Likewise in part (a)(ii) many correct references to the reaction reaching equilibrium or the hydrolysis going to completion were seen for one mark but not the reason for doing so. A notable minority have ‘heated under reflux’ always linked with oxidation but this was not the case here.

For the most part the practicing of graph drawing by candidates paid off and full marks were awarded in part (b)(i). It was pleasing to see that the vast majority of axes were correctly labelled with units.

The explanation of the plotting values was not well answered in part (b)(ii). Some of the more able candidates spotted that if the concentration of sodium hydroxide was plotted then because this does not change, the graph would be a straight line.

The determination of half-lives as seen in part (b)(iii) continues to show the misunderstanding by candidates when answers such as 12 and 24 minutes are given. The first half life is correct but the second should be 24 – 12 = 12 and this error was commonly seen. In part (b)(iv) it was often the case that candidates having quoted 12 and 24 minutes, still wrote that the half lifes were constant and so the order of reaction is first order. It is unclear if this is what these candidates have just learnt by rote when calculating half lifes or whether they had done the subtraction in their heads and simply not written the value down. This would be something that candidates and their centres would find useful to practice.

This is a long and exhausting paper and so it was pleasing to see that candidates maintained their efforts right to the end. The majority of candidates understood the significance of the slow, rate-determining step and correctly gave the rate equation for one mark. As this was the end of the paper, it was insufficent to simply identify Step 1 as the rate determining step for the second mark. It is the molar ratio of the species in this step that determines their reaction order and only the more able candidates explained that.

**Summary**

To improve their performance, candidates should:

- make sure that all necessary details are included in an answer, such as the commenting if a reaction is feasible or if the level of a chemical is acceptable
- be careful to strictly follow the rubric of the question so that if a name is required then give the name or if three aspects need commenting on then do include all three
- learn the definitions stated in the specification since even if not required quoting they do required using
- practice calculations ensuring that the layout of working is clear and labelled at each stage, taking care to ensure that the final units quoted are correct
- make time to read and then re-read the question to make sure that they are answering the question being asked
- always check the mark allocation of the question so that the depth of the answer given and the number of points being made matches the demand of the question
- keep in mind the stage or part of the experiment being referred to so that the answer given does relate to that particular step
- practice use of the Data Booklet, especially the spectroscopy information
- only give one answer to a question which requires just one answer
- take time to check an answer is fully correct and that all chemical terminology used is correct in its context

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