Examiners' Report
Principal Examiner Feedback

October 2020

Pearson Edexcel Advanced GCE
In Chemistry (9CH0)
Paper 3: General and Practical Principles in Chemistry

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Introduction

The cohort and the circumstances of those taking this examination were very different from all previous sessions. It was evident that many students were well prepared for this examination and were able to demonstrate that they had a sound knowledge of the topics in the specification. It was also clear that a significant number of candidates were lacking knowledge and understanding in several key topic areas.

Question 1

Many candidates knew the reagents required for the tests in both question parts. A relatively common error in (b) was the inclusion of sulfuric acid along with barium chloride/nitrate. Evidently these candidates did not appreciate that this acid would provide the sulfate ions being tested for. Another error in (b) but also seen in (a) was the wrong formula given for the reagent or product and so negated the mark. For example BaCl was frequently seen for barium chloride.

Question 2

The flame colours of the metal ions were generally well-known but there were some incorrect uses of 'brick-red' and 'green' for strontium in (a)(i). The concept of the brighter and stronger red colour of strontium masking the paler lilac colour of potassium in (a)(ii) was only grasped by the candidates of higher ability. Oftentimes references were made to the colours mixing and producing a new colour which is not true.

The majority scored one mark for the inertness of the nichrome or the reactivity of the iron wire. Only the more able candidates understood that the nichrome would not contribute any colour. A sizeable number of candidates suggested that the iron would have a higher melting temperature which is incorrect and would seem to counteract the point of the question why nichrome and not iron is used for the wire.

The questions on the steps and the use of acid in parts (ii) – (iv) enabled most candidates to gain credit. In (ii) some candidates referred to the wire being 'sanitised/sterilised/disinfected' which were ignored rather than penalised in this instance. However, it may be prudent to highlight that the process has nothing to do with microorganisms. Very few candidates appreciated in (iv) that the formation of volatile chlorides is the reason why hydrochloric acid is used. Credit was given however for the fact that the moist salts are then able to attach to the wire.

Explanation of the electronic transitions in the flame test are very well understood and most candidates scored full marks.

Question 3

Part (a)(i) was on the whole well-answered. A small minority of candidates appeared not to have properly read the question and commented on transfer errors in weighing the sodium hydroxide pellets. An insufficient answer referring to the solution would be diluted was often seen in (ii) but the removal of sodium hydroxide or the volume exceeding $250cm^3$ was needed. It was pleasing to see in (b)(i) that the majority appreciated the need to remove the funnel and to fill the tip of the burette before taking the initial burette reading. Likewise many correct comments on the diluting of the sodium hydroxide solution which would lead to an increased titre were seen in (ii).

There was good discrimination seen in the answers seen to part (c)(i). Good use of Data Booklet was evident with the colour change range of methyl red normally given. There was some carelessness observed in the reading of the pH values for the equivalence point or the vertical section of the line. Candidates are well-advised to annotate the sketch to obtain the correct values. The point most frequently missing was the explicit statement that the colour change of the indicator would be complete before the equivalence point was reached.

A significant number of candidates answered in terms of a replacement indicator for methyl red but this was not the question and so did not gain any credit.

Students need to practice calculations of percentage uncertainty because part (d)(ii) was very poorly answered with only a few correct responses. Some candidates who had the right idea then used the wrong volume and/or did not appreciate that the burette was refilled and so the measurement uncertainty had to be multiplied by four.

Part (e) proved an effective discriminator with a wide spread of marks observed. Advice for candidates is always to read the information carefully before beginning and to layout their answer clearly in order to identify the relevant steps taken.

Question 4

Many correct answers were seen in (a) but the less able candidates simply deducted the two masses which showed a complete misunderstanding of the process and that two marks were available so at least two mathematical processes will be required.

A wide range of answers were seen for (b) and candidates do not to consider if an answer is sensible. For example answers of a temperature change of over $600^{o}C$ in a polystyrene cup are not realistic. In addition temperature change accuracy of more than $\pm 0.1^{o}C$ are not detected in a school or college lab. It was also disappointing to see many candidates using 18200 or 18.2 for their value of Q instead of calculating the value from the data provided. Despite the question stating that an increase or decrease was required, this was frequently overlooked.

The drawing of the enthalpy level diagram on graph paper for (c)(i) was possibly the most disappointing on the paper. If the y axis was labelled, and this was rare, then the label was

most often ‘enthalpy change’ rather than ‘enthalpy’. The mark most frequently awarded was for the entities and their state symbols. The placement of the arrows to show the enthalpy changes was very poorly done. Candidates should note that, as in previous exam series, double headed arrows do not gain credit. Although the enthalpy change arrow and value can be reversed technically, this was not what the question asked and so this type of response did not score. Likewise in part (ii) the question explicitly stated in bold text that the working ‘must’ be shown on the diagram since this was part of the set task. A significant number of candidates did not fulfil this aspect of the question and so, despite getting the correct numerical answer, did not score the mark.
Answers to part (d) often referred to the process being endothermic or in need of heating which may relate to questions on previous examination but was not appropriate here. This reinforces the admonition to ‘read the question twice’ in order to answer the question set. Few candidates understood the impossibility of adding exactly five moles of water to each mole of anhydrous salt but some did gain credit for the difficulty of measuring the temperature change of a solid.

Question 5

In (a) more candidates had difficulty with the formula of the sodium benzoate rather than the inorganic species. At times an oxygen was missing from the benzoate and at other times the sodium ion was incorrectly shown with a covalent bond to the oxygen.
It was pleasing to see in (b) that most students seemed to have some experience of practical equipment, although it was not uncommon to see reference to the tap being opened without the separating funnel being inverted.
The answers seen for parts (d) and (e) revealed a poor understanding of the reasons for these practical steps which are similar to those in one of the core practicals. Centres are always encouraged to ensure that their candidates understand the reason for the practical steps that are taken. Reference to the solvent extraction of the sodium benzoate was needed in (d) and the protonation of the benzoate ion which resulted in lower solubility in (e).
Likewise centres are advised to practice drawing typical apparatus used with their candidates. From the diagrams seem it was evident that this is an area which requires more work. The need for a source of vacuum was the most common mark awarded but very few drew the perforated base of the Buchner funnel but instead drew perforations in the filter paper.
The calculation in (g) was generally well-answered. The most common error seen was the use of an incorrect molar mass value. Excessive significant figures were occasionally seen and must be avoided.
It was pleasing to see the majority of candidates understood that the presence of impurities lowers the melting temperature of crystals.

Question 6

An appreciable number of candidates in (a) simply copied the skeletal formula of phenol from the question above but this did not help with the balancing of the combustion equation; nor of the calculation to follow. Nevertheless the majority were able to score at least one mark for the correct species in the equation.

Candidates who find skeletal formulae challenging are advised to write out the formula in displayed form which was relatively easy in to with the formulae given at the top of the paper. It was evident in (b)(i) from the incorrect molar masses quoted that this would have helped a considerable number of candidates to avoid mistakes.

Parts (b)(ii) and (iii) were often answered correctly but some candidates did not read the question in (iii) properly and suggested either specific molecules rather than 'types'.

Part (b)(iv) was a novel question and aimed to differentiate the very best candidates which it was successful at.

Part (c)(i) was also an effective discriminator. Despite clear instructions in the question to include reference to 'bonds' and 'wavenumber ranges' there were still responses which did not refer to bonds or quoted single wavenumber values.

It was surprising that the answers on the C-13 NMR spectrum in (c)(ii) were rather poor. Candidates often quoted more wavenumber ranges than were correct and so these negated correct answers. It was also evident that a significant number of candidates are misreading the Data Booklet. For example it was not uncommon for the C-OH peak wavenumber range to go to 80 ppm but the 'lozenge' in the Data Booklet does not go anywhere near the 80 ppm mark.

The most common mass spectrum fragment ion seen in (c)(iii) was $COOH^+$ which was awarded the mark. Common errors included adding a bond before the fragment ion or either omitting the charge or even adding a negative charge. The question also asked for the *m*/*z* value which some of the lower ability candidates missed.

Question 7

This question elicited the full range of responses and so proved to be an effective discriminator. It was clear that some candidates had a very good knowledge of this topic area whilst other candidates wrote rather confused and contradictory responses. One particular error which centres would be well-advised to ensure is clear in the minds of their candidates is that the coordination number is not the number of ligands bonded to the central metal ion but rather is the number of coordination bonds between the ligand(s) and the central metal ion. A significant number of candidates did not get this correct. Another common issue was the inclusion of more than one complex ion example with the same geometry. For example the hexaaqua and the hexaamine complexes were on occasion both given and so both had to be correct for the mark to be awarded. The definition of a ligand was also often vague or absent despite the clear requirement given in the question.

Question 8

Candidates should always be remined that some transition metal complex ion colour changes just have to be learnt and recalled. In (a) those candidates who has studied this topic well scored both marks but others gave a wide range of colours and experimental observations.
The need for principles to be clearly understood was emphasised in (b)(i). Despite the request for an oxidation half-equation, responses frequently gave equations without the inclusion of electrons. This was aimed at the more able candidates and those capable of working things out were able to deduce the correct answer.
The equation for part (b)(ii) is explicitly stated in the specification and so should have been recall. Nonetheless it should be possible for the candidates to deduce from first principles and so the more able were able to score the mark as well as those whom had simply learnt it.
Part (b)(iii) is a classic example to remind candidates of the need to read the question carefully and to answer accordingly. It specifically states that the oxidation and reduction half equations were required but oftentimes no labelling of the half equations were given. The cell diagram notation was a new addition to the specification but this is several years past now and so should be more familiar. However some responses led examiners to speculate that this is still a rarely considered part of the topic area. However the more able candidates could demonstrate their understanding and scored the marks.
The modal mark for the labelled diagram of the electrochemical cell apparatus was five. The majority of candidates included the voltmeter, salt bridge with chemical, platinum electrode for the chromium electrode and the need for 1.0 mol dm^{-3} concentrations. At times candidates were careless with their diagrams and did not have their salt bridge in their solutions and so lost one mark for this. The two marks which were not awarded very often were for the formulae of the compounds required which was despite the word 'formulae' being emboldened. Candidates need to be observant and to notice this type of font as indicating exactly what is required in their answer.

Question 9

The few correct answers to (a) on the preparation of amines suggests that this is a topic area not well-studied or understood. Candidates need to remember that 'compare and contrast' question need at least one similarity and one difference. The similarity of both reactions being that of reduction was rarely given and instead vague or feeble answers such as both require heat were seen.
The comparison of the basicity of the two amines in (b) was answered much better. However it is worth highlighting that candidates would be well-advised to ensure that when answering

questions of this type that terms such as 'base' are clearly stated. The lone pair of electrons on the nitrogen is the key aspect of this subject and how it is able to form a coordinate bond with a proton and thus act as a base. Only the better candidates made this clear. It was not uncommon to see a response where the proton was not mentioned at all.

It is worth reiterating that questions further along in the paper get more demanding. This was clearly evident in part (c). The equation for the reaction warranted only one mark. Common errors were the use of molecular formulae and the omission of the product HCl. The name of the amide was also problematic for all but the more able.

Polymers continue to be challenging for candidates and centres would be helpful to provide even more practice. The name of the amine monomer given was not always the systematic name but credit was attempted to be given where it was unambiguous.

Question 10

The need to add curly arrows in (a)(i) revealed that many candidates have failed to grasp that these arrows should start from a lone pair of electrons or a covalent bond and show the movement of an electron pair. The lack of understanding of this crucial key point was most clearly seen in the first step where the curly arrow was often drawn originating from the proton instead of the oxygen lone pair. However this did prove to be a most effective discriminator and enabled those candidates who really understand this topic to score highly.

The justification required in (a)(ii) was often very superficial, such as 'the oxygen comes from the ethanol'. This was another question aimed at the more able and this category of candidates were able to either refer to the nucleophilic action of the ethanol oxygen or that the carbon-oxygen bond in the carboxylic acid was the one broken.

It may be due to the lengthy nature of paper 3 that many candidates did not progress further in the entropy calculation of part (a)(iii) beyond the M1 mark. The rearrangement of the Gibbs Free Energy equation proved beyond many and it was disappointing that the instruction to include sign and units in the final answer was frequently ignored. Nonetheless there were a significant number of candidates that scored full marks.

The final question (b) required three differences and so it was not sufficient to simply state that one reaction for example produced hydrogen chloride. It was necessary for the response to state that the other reaction, namely with ethanoic acid, produced water and so clearly state the difference. The hardest of the three marks proved to be that an acid catalyst is required with ethanoic acid with few candidates going on to state that the reaction with ethanoyl chloride is faster/does not need heating and so does not need a catalyst.

Summary

In order to improve their performance, students should:

- read the question carefully and make sure that they are answering the question that has been asked
- write concisely and avoid making the same point multiple times
- make sure that comparisons are made when required
- write suitable or appropriate formulae and numbers carefully, checking their legibility
- be careful with the precision of curly arrows in organic mechanisms
- show all working for calculations and give final answers to an appropriate number of significant figures, including stating any units if required
- make sure they understand the difference between reagents and conditions, including when catalysts are involved
- remember and apply the meaning of key terms such as oxidation and reduction
- allocate time towards the end of the examination to reread questions and answers, and so avoid careless mistakes.

Grade Boundaries

Grade boundaries for all papers can be found on the website at:

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