



# Examiners' Report Principal Examiner Feedback

October 2020

Pearson Edexcel Advanced GCE  
In Chemistry (9CH0)  
Paper 1: Advanced Inorganic and Physical  
Chemistry

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## Introduction

Some candidates were well prepared for this examination and were able to demonstrate that they had a good knowledge of the topics in the specification. In particular, familiar quantitative problems proved accessible as did explanations with a 'stock' answer such as the trend in thermal stability of Group 2 nitrates. Issues still persist with the ability of candidates to explain solubility, especially in the context of a free response format, and novel contexts still provide challenge for many.

## Question 1

The multiple choice questions allowed many candidates to start confidently, as did part (d). However, a minority made an unforced error here by giving the symbol for neon. Some candidates seem to assume isoelectronic means an ion with the same overall charge, so suggested group 2 ions such as  $\text{Ca}^{2+}$ .

In (e), many candidates were able to justify why scandium and zinc are not classified as transition metals, with clear reference to the electronic configurations of stable ions. A number believe that the reference to an incomplete d-subshell applies to the atom, and this view persisted with examiners seeing examples of atomic configurations with no discussion of the ion formation. The ability to define what is meant by a d-block element proved discriminating, with many circular answers along the lines of 'they are d-block elements because they are in the d-block of the Periodic Table' failing to score.

## Question 2

The skill needed to interpret '>' in the context of decreasing pH providing an unexpected degree of challenge in (a), however many candidates managed to score full marks in (b) with only a small number forgetting to convert  $K_a$  to  $\text{p}K_a$ . In (c) it was common to see students focus on the pH and suggest A, either not spotting or not appreciating the fact that the mixture was a buffer solution. In (d) incorrect answers were common. Presumably because some candidates did not recognise ammonia and ethanoic acid as a weak base and weak acid respectively, or they were unaware that indicators do not show the end point of this titration effectively.

### Question 3

Most candidates had some knowledge of metallic structure, and the candidates with an eye for written detail and who took care with any diagrams were able to score full marks. Probably the most common issue with diagrams was inconsistencies with the number of electrons shown. For instance the ion would be shown as  $\text{Cr}^{3+}$ , but too few electrons were then evident in the diagram. Written answers did not always refer to the regular arrangement / lattice of ions, hence without a diagram to support the comments, the first mark could not be awarded. Some confusion persists with the electrostatic attraction in the model. Many referred to an attraction between the nucleus and the outer electrons hence it was not always clear whether the discussion was based around ionisation of metallic bonding.

A small number of candidates needed to take care when reading the question as they described bonding in chromium complexes and tried to justify a high melting temperature in this context.

In (b) most candidates could describe the shape of the complex, but once again some did not read the question and gave its formula. In (ii) most candidates realised that the d-orbitals / subshell splits in a complex ion. A number were imprecise with language though and did not score the first mark as they described a singular 'd-orbital' as splitting. Many understood the colour was linked to electron promotion, though disappointingly many linked this to the return of the electron to the ground state and subsequent emission of light, as in a flame test. Most candidates recognised the increases in entropy in (c), linking it to the increases in the number of moles of particles, though far fewer appreciated that the value of the equilibrium constant meant the complex was stable or the equilibrium position was far to the right. The calculation in (d) allowed nearly all candidates to access some credit, with the first 2 marks often awarded. Although the molar volume of a gas was given in the question, a number of candidates attempted to find the moles of chlorine using the ideal gas equation, making life more difficult for themselves. The ability to link the transfer of electrons to the ratio was discriminating, and such candidates often went on to score full marks in (i) and (ii). Some answers found it difficult to process the idea that this was an oxidation from +2 to +5, and focused on the more usual reduction from +5 to +2, giving the colours the wrong way round.

#### Question 4

Parts (a) and (b) were accessible to most candidates, but part (c) provided a significant degree of challenge for all. The best answers took time to structure their response into discrete sections, in each case considering correctly the types and relative strength of forces present in the solute and solvent individually and any potential resultant solute-solvent forces.

However, a number of responses didn't develop much beyond the idea of 'like dissolves like' so struggled to access the higher marks. Those who did discuss the forces often made mistakes. For instance, it was common to see the alkanes described as having London forces and dipole-dipole attractions and many described potassium bromide as a polar molecule often frustratingly in the same paragraph as discussing its ions. Few candidates realised that water molecules would hydrate the ions, with a number explaining its solubility with the claim the London forces between the ions and water would compensate for the breakdown of the lattice.

#### Question 5

Nearly all candidates could suggest at least one relevant observation in (a)(i), with brown gas and white solid probably the most common creditworthy answers. Effervescence alone was not worth credit in this context and a number described the test for oxygen, which did not score, as essentially the candidate seemed to be making up their own question.

In (ii) the first two marks linked to ionic size and polarising power were common. Pleasingly there seemed to be fewer answers referring only to atoms than in previous series. Perhaps as expected the third mark was discriminating. Of the candidates who discussed the impact of the polarisation of the anion on bonding, the view persists that it is the impact on the ionic bond between the ions rather than the covalent bond(s) within the anion that explains the trend in thermal stability.

In (b)(i) the dot-and-cross diagram was drawn accurately by many, with some candidates taking great care to show the origin of the electrons. A number of candidates scored only 1 mark as they split the hydroxide ion into separate oxide and hydrogen ions, whilst others drew a shell of 8 electrons around a central 'OH' rather than show the bond pair between them. Even with a reference to ions in the question, covalent dot-and-cross diagrams were seen more often than one would like.

The calculation in (ii) allowed many candidates to show a range of elegant solutions, with the calculation of the relative formula mass of the hydrated salt and subsequent deduction of the relative mass of water molecules present being the most common route. Even less able candidates could access marks 1 and 2, though after then errors started to creep in, most commonly the calculation of the mass of water, or when working out the relative mass of anhydrous magnesium nitrate.

### Question 6

Although many candidates realised that a double bond consists of a pi and sigma bond, far fewer were able to use this effectively to justify why the student was incorrect in (a)(i), with most answers simply stating that the double bond was stronger or shorter than the single bond.

Nearly all candidates knew how to approach the calculation in (ii) and fully correct answers were seen by a range of candidates. Common errors included omission of the value for breaking bonds in the oxygen molecules, reversing the values to give an endothermic answer, and transcription errors with numerical values. Transferred errors meant award of some credit was possible in most of these cases. In (a)(iii) most answers gave a generic discussion of entropy, and tended to only score 1 mark for the justification of an entropy increase. Only a few answers made an effective distinction between  $\Delta S_{\text{total}}$ ,  $\Delta S_{\text{system}}$ , and  $\Delta S_{\text{surroundings}}$ . Even those who chose to base their answer on  $\Delta G = \Delta H - T \Delta S_{\text{system}}$ , often omitted to mention  $\Delta S_{\text{system}}$ .

The calculation in (b) was often well laid out, with a clear route through the problem shown by many. A few candidates were inconsistent with units for entropy, and others missed out on the final mark as they didn't comment on the feasibility of the reaction in light of their answer. Some candidates spent time doing additional unrequired work, by also calculating  $\Delta G$ , but more problematic was the small number who ignored the instruction to find  $\Delta S_{\text{total}}$  and tried to base their response solely on  $\Delta G$ , often making errors in the process.

### Question 7

The majority of candidates could write the correct equilibrium expression in (a)(i), with the most common error being the omission of water. However, the unfamiliar style of calculation in (ii) proved challenging for all but the most able. Most candidates did not consider that the number of moles of product formed could be linked back to the moles of reactant remaining and simply assumed that 1.2 mol of each reactant will still be left at equilibrium. Some did appreciate the link, deducing  $1.2 - x$  mol of reactant would remain, where  $x$  = the number of moles product formed. Only a small number then realised they could input their findings into equilibrium expression and simplify it by taking square roots, without the need for a quadratic equation. Most candidates who scored 3 marks did so by writing and solving the quadratic equation.

Questions similar in format to (b)(iii) have been asked many times, and the simplest answers were often the highest scoring, based on the idea that only temperature affects  $K_p$ . Some of those who started to discuss the position of the equilibrium moving to the right made the mistake of thinking this would increase  $K_p$ , though perhaps more than in the past linked this movement as a way of keeping  $K_p$  constant.

### Question 8

The colour change in (a) proved to be more challenging than imagined with a number only giving one colour or giving the reverse answer. A few didn't appreciate that at the end-point only a very small amount of potassium manganate(VII) will be in excess and hence thought the reaction mixture would be purple, rather than pale pink.

In (b) the covalent dot-and-cross diagram was found difficult by many. Some seemed to have recalled the displayed formula of the ion and translated the bonds accordingly. However, some others simply added lines to the diagram, without showing electron pairs. Others didn't manage to deduce the correct number of electrons, forgetting the two extra electrons or simply not adding correctly. Perhaps the most frustrating 1 mark answers showed all the bonding electrons correctly but omitted the non-bonding electrons.

In (c), despite the equation in the stem, many thought the sulfuric acid was a catalyst.

The cell diagram in (d) was presented correctly by a small number of candidates. Some confused the idea of a cell diagram with a diagram of the apparatus needed to set up the cell, whereas others mixed up the use of solid lines, showing several in their diagram, rather than the two needed to separate the platinum electrodes from the rest of the cell diagram. The R-O-O-R convention was not always implemented and the majority of answers did not include key cell reactants such as  $\text{H}^+$  ions and  $\text{H}_2\text{O}$ .

In (e), a disappointing number of unforced errors were seen in the table. Most common was the use of 1 decimal place for titration data, whilst other candidates did not recognise concordant results, so calculated the mean of Runs 1, 2 and 3. Once again nearly all candidates gained some credit for the calculation in (ii), though sometimes the ratio for the second mark was inverted. Several candidates calculated the concentration of the  $\text{KMnO}_4$ , an unnecessary step which then confused many of this cohort. Stronger candidates were able to get back on track, by calculation the moles in  $100\text{ cm}^3$ , whilst the best candidates didn't calculate the concentration, but simply scaled from  $10\text{ cm}^3$  to  $100\text{ cm}^3$ . Some otherwise good answers missed out on credit in marks 4 and 5, either by missing potassium when determining the relative formula mass of potassium manganate(VII) or by not converting their answer to mg. In (iii) most answers recognised the role of  $\text{Mn}^{2+}$  as an autocatalyst, and many linked the slow initial reaction to the repulsion of two negative ions or the resultant high activation energy. The most effective way to score marks 3 and 4 was to write equations for the appropriate reactions using the half cell data. Those who tried to justify in prose often gave answers that lacked clarity, with descriptions that confused the key reactions, for instance describing  $\text{Mn}^{2+}$  as oxidizing the  $\text{MnO}_4^-$  ions.  $E_{\text{cell}}$  was also used ineffectively, either

because candidates simply calculated a value of + 0.87 V for the overall reaction, or because they did not relate + 0.85 V or + 0.02 V to the appropriate reaction. A small but noticeable number tried to link  $E_{\text{cell}}$  values to rate, confusing thermodynamic and kinetic stability.

## 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
- ensure they can define what is meant by a d-block element
- make sure that any diagrams given do not contradict any subsequent text in an answer
- plan your answer to free response questions by splitting your work into small sections, based on the question requirements given in the stem, before you start to write at length. This will stop you repeating yourself unnecessarily and help give more structure to your comments.
- make sure you can justify reaction feasibility both in terms of  $\Delta S_{\text{total}}$  and  $\Delta G$ .
- refer to  $\Delta S_{\text{total}}$ ,  $\Delta S_{\text{surroundings}}$  and  $\Delta S_{\text{system}}$ , when appropriate, not just 'entropy'
- practice drawing dot-and-cross diagrams for a range of ions
- practice drawing cell diagrams other than simplistic examples such as the one that represents the Daniel Cell
- practice a wide range of titration problems to help you develop bespoke solutions to problems, rather than trying to rely on generic methods
- reread questions and answers, where time permits, to minimise careless mistakes.

## Grade Boundaries

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

<https://qualifications.pearson.com/en/support/support-topics/results-certification/grade-boundaries.html>



