Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

January 2024

Pearson Edexcel International Advanced Subsidiary Level In Chemistry (WCH12) Paper 01: Energetics, Group Chemistry, Halogenoalkanes and Alcohols

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Introduction

While many excellent responses were seen to all questions, a significant proportion of the candidates appeared to have a limited knowledge of the specification content or were not confident in applying this. In general, the candidates were most confident in performing calculations and in answering well-practised questions, such as using a Maxwell-Boltzmann distribution to explain the action of a catalyst.

Section A

The mean score for the multiple-choice section was 10.2. The highest scoring question was Q1 with almost 95% of candidates scoring this mark. The most challenging questions were Q3, Q18 and Q19 with less than 30% selecting the correct answer for each.

Section B

Question 21

Most candidates gave the correct electronic configuration for calcium, however, a common mistake was to fill the 3d subshell before 4s. Candidates were familiar with the concept of oxidation number in (b)(i), though some did not follow instruction and gave an explanation in terms of electron transfer. A common error was to give the oxidation number of chlorine as -2 in calcium chloride. While most candidates gave correct responses in (b)(ii) and (iii), some gave an incorrect description of the (brick) red flame colour of calcium. In general, candidates did not seem familiar with the experiment in (c)(i) or understand that nitrogen dioxide is an acidic gas; many stating that the indicator would turn blue, presumably thinking that calcium oxide would enter the water. Candidates should be reminded of the difference between effervescence and bubbles of gas passing through a liquid. Most candidates struggled to convey a clear understanding of the thermal decomposition of Group 2 nitrates in (c)(ii) with many referring to general trends in reactivity, solubility, or boiling/melting temperature. Of those who understood the chemistry involved, many gave vague responses referring to magnesium or calcium (atoms) as opposed to their **ions**, and many demonstrated a misconception that it was the (ionic) bonds between metal cation and nitrate anion that broke in the decomposition. Overall, the candidates struggled to convey an understanding of the reaction of Group 2 elements with water in (d), with many confused accounts of solubility trends and general reactivity trends presented. Where the reaction was better understood, a lack of attention to **observations** was commonplace, for example referring to the production of hydrogen gas as opposed to bubbling. A poor understanding of the pH of the solution produced was frequently demonstrated, with a significant number thinking the indicator would change colour to orange/red. Many candidates did not seem to have any practical experience of these reactions, with many incorrectly thinking the reaction with magnesium would be more vigorous or referring to the reaction of magnesium with steam, even though the question clearly stated cold water.

Question 22

Most candidates recognised that 1 mol of compound was being formed in Reaction 1, but many referred to standard conditions instead of elements in their standard states. While most candidates were familiar with the method of calculation in (b), full marks were not commonly awarded due to careless errors such as: ignoring instruction and giving the final answer to too many significant figures; failing to appreciate that the increase in temperature indicated an exothermic reaction and that $\Delta_r H_2$ should have a negative sign; a spurious calculation for the total mass of solution even though this was provided in the question; a spurious calculation involving the moles of hydrochloric acid even though this was stated to be the excess reagent. Many candidates were unable to correctly relate the data or their answer to part (b) to the enthalpy cycle in part (c), indicating that candidates would be benefit from greater opportunity to practise unfamiliar Hess cycles.

Question 23

In part (a), candidates were more confident in giving the displayed formula of 2-bromobutane than the skeletal formula of 1-bromo-2-methylpropane, with 2-bromopropane being a common incorrect structure for the latter. Similar proportions were able to identify the tertiary isomer by name and formula in (a)(i) and (b). Those candidates who had learnt the details of the reactions of halogenoalkanes stated in the specification scored well in (c)(i): common mistakes typically centred around the conditions, with many omitting either heat or aqueous in R1; and either ethanol or under pressure in R3. Many candidates were well practised in the mechanism for the nucleophilic substitution reaction in (c)(ii), however, many chose to add negative charges to the ammonia molecules and the placement of lone pairs was often careless, with one or both electrons spanning the hydrogen atoms. Candidates were less familiar with the nitrogen of the ammonium salt intermediate carrying a positive charge; when this was correctly shown, many drew a curly arrow from the second ammonia molecule to the positive charge, failing to appreciate that this would not lead to the formation of the products shown. Candidates should be encouraged to understand bond formation and bond fission in curly arrow reaction mechanisms wherever possible. Most candidates scored well in (c)(iii), common mistakes included giving CN or C–N instead of the **triple bond** between the C and N atoms, or confusing R4 with R3 and giving the wavenumber range for an N–H bond.

Section C

Question 24

Deducing the correct numbers of bonds proved to be the most challenging aspect of the calculation in (a)(i) with many thinking there are 48 bonds in 24 molecules of F_2 or that there were either 8 or 6 (and not 8 × 6) bonds in 8 molecules of SF_6. Those who ended up with a negative sign should have realised that breaking bonds requires energy and so bond enthalpies are endothermic, prompting a check of their calculation. While many candidates appreciated that mean bond enthalpies are

average values that apply to the gas phase, only a small proportion were able to link this to an inaccurate bond enthalpy of **solid S_8** used in the calculation. Many candidates overcomplicated the calculation in (a)(iii) through use of the Avogadro constant, which was unnecessary as the ratio of the molecules is the same as the moles. It was disappointing to see several basic errors, such as failing to convert the mass of carbon dioxide from kg to g, or incorrectly calculating the molar mass of SF_6. Only a small proportion of the candidates were able to give the correct answer in (b)(i), failing to use the information provided or to appreciate that NaClO is dissociated in solution. In (b)(ii), many candidates realised that toxic chlorine gas would be produced but were less confident in using the equilibria to explain how this happened. In questions involving equilibria, candidates should be encouraged to apply Le Chatelier's principle to frame their responses in terms of equilibrium shifts as clearly as possible – the information provided in the stem of the question was intended to help candidates do this. In (b)(iii), most candidates did not relate the reaction to the disproportionation of chlorine in hot alkali and were unable to generate the correct equation, even though the names of the products were given. The main errors in (c) were incorrectly deducing the molecular formula of the fire retardant and failing to follow instruction and give the answer to an appropriate number of significant figures, which was two or three, based on the relative atomic mass values from the Data booklet. While most candidates understood the general form of a Maxwell-Boltzmann distribution in (d), many careless errors were seen: poor labelling of the axes; failure to start at the origin; touching/crossing the x-axis at high energy; finishing at too higher energy or showing positive curvature at high energy; showing confusion with the effect of temperature and giving more than one distribution. It was disappointing to see a significant number of candidates draw a reaction profile in place of a Maxwell-Boltzmann distribution. When explaining factors affecting reaction rate, candidates should be discouraged from making generic references to successful collisions and instead more precisely refer to the number of particles/collisions possessing energy equal to or greater than the activation energy.

Summary

Based on their performance on this paper, candidates should:

- read questions carefully and answer the question that is being asked
- where possible, gain practical experience of reactions stated on the specification (eg the reaction of Group 2 elements with water / the thermal decomposition of Group 2 nitrates and carbonates)
- practise application of Hess's Law to unfamiliar enthalpy cycles
- give thought to significant figures, signs and units in enthalpy calculations
- learn the reagents and conditions for reactions stated in the specification
- develop their understanding of bond fission and bond formation in curly arrow mechanisms
- carefully consider the question context before providing a generic response
- practise application of Le Chatelier's principle to explaining equilibrium shifts in reversible processes
- use past papers to improve their precision of the required terminology

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