Examiners' Report
Principal Examiner Feedback

November 2021

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

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November 2021
Publications Code 9CH0_03_2011_ER

Introduction

Some candidates were very well-prepared for this examination and scored high marks. Many candidates were able to demonstrate that they had a sound knowledge of the topics in the specification and could apply this to the questions with just a few omissions or errors. Other candidates found the paper challenging and would benefit from more preparation to ensure that they know the basic facts, are familiar with the standard practical techniques, can express their ideas clearly and carry out calculation, explaining their working.

Question 1

The majority of candidates could complete the table to show the numbers of subatomic particles. However, some candidates did not realise that a negative ion gains an electron. The mass spectrum in (a)(ii) proved much more challenging for many candidates. Some candidates worked out that there would be peaks at m / z values of 70, 72 and 74 for the molecular ion but only a small number could work out the ratio of the heights of the peaks. The most common error was to omit the peak at 72. Many candidates were unable to write the formula for potassium chlorate(V) and many used incorrect symbols, e.g., P for potassium, and oxygen omitted. Many candidates could write the equation for the first electron affinity of chlorine, but some wrote the equation for first ionisation energy and others included Cl2. Many candidates omitted the acid from the oxidising agent in (d)(i), although they could still score the mark for calculating the Eocell value. Those that chose an incorrect oxidising agent should have checked their answer when their Eocell value was negative.

Question 2

A low number of candidates knew a chemical test for a carboxylic acid. Some suggested the use of phosphorus(V) chloride but that would also give a positive result for the OH group in substance B. The use of an indicator is not classed as a chemical test so was not given full credit. A larger number of candidates knew how to test for an alkene using bromine water. The majority of candidates could select the correct wave number ranges from the Data Booklet for (c). However, some did not read the question carefully and wrote ranges outside of the 1800-1600 cm−1 range specified.

Question 3

The vast majority of candidates completed the electronic configuration of an aluminium atom, with just a small number including electrons in d orbitals. The dot-and-cross diagram for aluminium chloride was shown clearly by many candidates, although some included a lone pair of electrons on the aluminium atom and others showed ions. The shape and bond angle of aluminium chloride were correct in many responses, but some candidates did not use their dot-and-cross diagram to help and others suggested shapes with a different number of atoms, e.g. tetrahedral which would show the presence of four chlorine atoms. The mechanism for the alkylation of benzene was answered well by many candidates, with slips such as not starting and ending curly arrows in the correct places or poorly drawn intermediate. Some candidates would benefit with much more practise at drawing organic mechanisms accurately. Many candidates seemed unfamiliar with how two aluminium chloride molecules join together to form a dimer and many bonds between aluminium atoms were seen. Some candidates knew that dative covalent bonding was involved but some showed the lone pair of electrons donated from an aluminium atom to a chlorine atom.

Question 4

Many candidates could draw the curves on the graph for Experiments 2, 3 and 4, with 4 being the least well done as many did not realise that doubling the concentration would increase the rate as well as double the amount of gas lost. A number of candidates lost a mark in (b) as they did not draw a tangent to the curve to calculate the initial rate or drew it in the wrong place. Many candidates struggled to describe an alternative way of carrying out the experiment that involved collecting the gas produced. Candidates were expected to be familiar with the use of a gas syringe or collecting the gas over water in an upturned measuring cylinder to measure the volume of gas collected at regular time intervals. Many candidates lost marks by careless diagrams showing apparatus that would not work or by omitting important details such as replacing the bung on the flask as soon as the reactants were mixed.

Question 5

Some candidates were familiar with the tests for ions listed in the specification so answered this question very well. Others would benefit from much more practise at this style of experiment and question. Many candidates recognised the test for a sulfate ion in X but far fewer identified the iron(II) cation. The ionic equation for the reaction between the cation and aqueous sodium hydroxide was poorly answered. Many candidates did know that the precipitate would be oxidised by air, even if they didn't know what the precipitate was. Many knew that hydrochloric acid was added in Test 2 to remove any carbonate ions to ensure they did not give a precipitate with aqueous barium chloride. The tests for copper(II) ions and chloride ions were often known, although there was some confusion with chromium, cobalt or nickel ions. The formula of the complex ion in the deep blue solution was rarely done correctly, with many not even including ammonia ligands. Many candidates did know how to confirm the presence of chloride ions.

Question 6

Some candidates gave clear and concise explanations for why phenol can be nitrated using milder conditions than benzene while others seemed unfamiliar with this concept or gave partial answers. Some referred to the lone pair of electrons on the OH group rather than the oxygen atom. Many candidates struggled to explain the difference in boiling temperatures of the two isomers and did not refer to intermolecular forces as requested in the question. Many answers did not mention hydrogen bonding. Many candidates knew that a reducing agent is needed to convert 4-nitrophenol into 4-aminophenol, although some did not read the question and gave a specific reagent rather than the type of reagent. There were many poor diagrams drawn for filtration under reduced pressure, with folded filter paper and no perforations in the Buchner funnel. Most candidates would benefit from more practise in drawing clear labelled diagrams of the common practical techniques in the specification. A few candidates gave clear descriptions of the recrystallisation procedure, but most put steps in the wrong order, missed out steps such as hot filtration and were generally confused. A common error in producing dry crystals was to suggest adding an anhydrous salt as a drying agent. Although this works well for drying liquids as it is easy to separate the substances, it does not work for drying crystals unless the drying agent is specified as being in a desiccator. Many candidates knew that impurities lower the melting temperature of a substance and it will melt over a range of temperatures rather than having a sharp melting point, but many omitted one of these from their answer. Many candidates were able to work out the molecular formula of paracetamol but quite a lot had an incorrect number of hydrogen atoms and some candidates were not aware of the meaning of molecular formula. The calculation in (d)(ii) was carried out correctly by many candidates. Some omitted to use the mole ratio and others omitted the use of a 100.0 cm3 volumetric flask. Some candidates calculated a mass higher than the original 0.500 g of paracetamol and reversed the percentage calculation to obtain a value less than 100%. These candidates should be advised to check their working to see where they have made an error instead of doing this.

Question 7

The first parts of the calculation in (a) were answered well by most candidates, although some did not state how they knew that hydrochloric acid was in excess. Many candidates made errors in the calculation of the enthalpy change in (a)(iii). Some added the mass of sodium hydrogencarbonate to the mass of the reaction mixture, some just worked out the heat change for the amounts used and others included a minus sign so thought it was an exothermic reaction, even though there was a fall in temperature. The Hess cycle in (b)(i) was very poorly completed, with it being extremely rare to see the correct amounts of the correct substances in the box at the bottom of the triangle. Some candidates did have the arrows pointing in the correct directions. Many candidates omitted to multiply the enthalpy change for Experiment 1 by 2 and a lot were not sure how to carry out the calculation in (b)(ii). Most candidates would benefit from more practise at drawing Hess cycles and using them to calculate an enthalpy change. The percentage error in (c)(i) was often correct, although some candidates calculated an answer as 82.2% and did not subtract this from 100 to obtain the percentage error. Some candidates calculated the percentage uncertainties in the measuring cylinder and burette correctly, although some thought there were two readings for a measuring cylinder and only one for a burette. Just a small number of candidates realised that the uncertainties in the measuring instruments were considerably less than the overall percentage error in the student's value. Few candidates seemed familiar with measuring temperature at regular times intervals, plotting a temperature vs time graph and extrapolating the lines to obtain the maximum temperature rise in (c)(iv).

Question 8

Many candidates were familiar with the 'iodoform' test to identify a methyl ketone, although some lost a mark as they did not mention the reagents as aqueous iodine and aqueous sodium hydroxide. The mechanism was well drawn by a few candidates, but many made a mistake such as not starting a curly arrow from a lone pair or a bond or drawing an incorrect intermediate. Some candidates seemed unfamiliar with this mechanism and produced a carbocation before attacking with cyanide ions. Many candidates realised that the nucleophile could attack the intermediate from either side but most omitted to mention that the intermediate is planar around the carbonyl carbon. Many candidates used the data to identify the correct aldehyde, but they did not score full marks unless they justified their answer using all of the data. For example, many did not show the three carbon environments and two hydrogen environments. The extended open response question was answered well by many candidates, showing that they had a good knowledge and understanding of the redox reactions of carbonyl compounds. Some candidates lost marks as they did not draw the structures of the products, did not show five of carbon atoms in the products, confused oxidation and reduction and omitted part of the oxidising agent or reducing agent, for example the acid from potassium dichromate or the dry ether from lithium tetrahydridoaluminate. Some candidates showed a lack of understanding and referred to pantan-3-one as a tertiary ketone and reduced it to pentan-2-ol instead of pentan-3-ol.

Question 9

The majority of candidates could explain the effect of increasing the pressure on the equilibrium yield of ammonia, with just a few confusing right and left. The unfamiliar calculation in (b) was generally well answered, with marks available for substitution of correct numbers into the expression and rearranging it. Many candidates were unable to substitute the units into the expression to work out the units of Kc. The majority of candidates found the calculate in (c) to be very challenging. Most candidates were unable to work out the number of moles of each substance at equilibrium. However, they were able to score transferred error marks if they could complete the calculation with their values.

Unfortunately, many were unable to work out the mole fractions and partial pressures. Some candidates tried to use the ideal gas equation. Many candidates were able to substitute the correct values into the expression in (d) and evaluate the right-hand side so received credit for this. Some candidates were then able to rearrange the expression and calculate a correct value for the equilibrium constant at 310 K.

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
- learn the meanings of all the key terms in the specification and use correct scientific terminology in their answers
- write concisely and avoid making the same point multiple times
- 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 units where appropriate
- practise drawing laboratory apparatus for the techniques in the specification
- practise describing all the steps in an experiment or ways of improving an experiment
- reread questions and answers, where time permits, to avoid careless mistakes.

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