



Examiners' Report Principal Examiner Feedback

November 2021

Pearson Edexcel Advanced GCE
In Chemistry (9CH0)
Paper 2: Advanced Organic and Physical
Chemistry

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

November 2021

Publications Code 9CH0_02_2111_ER

All the material in this publication is copyright

© Pearson Education Ltd 2021

Introduction

Some candidates were prepared for this examination and were able to demonstrate that they had a strong knowledge of the topics in the specification. Familiar mechanisms such as electrophilic addition to alkenes proved a strength for many, and most candidates were able to manipulate straight forward mathematical expressions, such as $pV = nRT$. However, other quantitative problems proved challenging, and whilst this was perhaps expected in Q06(c)(i), Q08(a) and Q08(b) both had familiar contexts, but still proved challenging for many. The later questions, as expected, proved demanding, but a disappointing number of candidates didn't attempt significant sections of questions in Q09, Q10, Q11 and Q12.

Questions 1, 2 and 3

Although nearly all candidates could calculate the amount of ammonium sulfate in Question 1, as shown by the number who incorrectly chose B, far fewer seemed to focus on the bold text 'ions' and hence deduce D.

Question 2 was more accessible, and a significant proportion of candidates were able to process the ratio correctly to arrive at the right answer.

Juggling both the position of the double bond, the methyl group as well as determining the nature of stereoisomer was difficult for many in Question 3.

Question 4

Again, the text in bold seemed to be ignored by many, as a number of candidates produced isomers based on a linear five-carbon chain, with no branches. It was common to see two pent-1-ene structures proposed, though drawn differently. For instance, the C=C bond would be shown on the far left in the first answer, then on the far right in the second. Others simply angled their second attempt up or down the page, but did not spot that it was still a five-carbon chain.

Other candidates could draw a correct structure, but as described above, drew it again in a different orientation, thinking this was a new isomer. A majority of candidates could identify which alcohol would form pent-2-ene in (b) and the mechanism in (c) was confidently handled by many. The most common issues were ones of detail, with the omission of key features such as the dipole on the H-Br molecule, and a lone pair on the bromide ion. A frustrating minority ignored the instruction in the question and showed 3-bromopentane as the product. The calculation in (d) showed most candidates have a secure understanding of the Ideal Gas Equation. However, minor slips meant some candidates did not access all four marks. These included:

- using an incorrect relative molecular mass of pent-1-ene to determine n
- incorrect conversion of temperature to K and/or volume to m^3
- incorrect number of significant figures and / or units

A small number of candidates converted the volume to dm^3 . Sometimes this seemed to be a deliberate strategy, with the candidate realising that this results in a pressure measure in kPa. Others, however, may have confused the units with those required in titration problems, and hence made errors in the final units for pressure. Candidates need to be careful that their rationale is clear if they adopt this route, and the best way is to ensure all steps of the calculation are clearly labelled and presented in a clearly defined order.

Question 5

In (a) many candidates mistook the ester group for a carbonyl / ketone group, so could only score a maximum of one mark. Others focused on the left of the structure and omitted the alkene group. In (b) the hint of 'a chemical reaction' seemed to be missed by many, who framed their response exclusively around the idea of hydrogen bonds with water. Those candidates who realised a hydrolysis reaction could occur, not all linked it to the ester functional group. In (c)(i) fractional distillation was correctly suggested by nearly all candidates. In (b) the majority recognised that X had the ability to form hydrogen bonds, but some missed out on the first mark as they didn't link this statement to a structural feature on compound X. Others, however, made a comparison to the London forces in a similar hydrocarbon, so were able to access both marks. Despite the stem making it clear the hydrocarbon had a similar mass and shape to compound X, it was fairly common to see answers trying to make the point that compound X had greater London forces.

Question 6

The unfamiliar 'dot and cross' diagram in (a) was interesting in the sense that there didn't seem to be a correlation between ability on the rest of the paper, and gaining credit here. It was common to see a double bond between the carbon and the oxygen, with candidates then either leaving the carbon atom electron deficient or incorrectly introducing additional electrons.

The very familiar atom economy calculation in (b) was accessible to the majority, perhaps not surprising as it also forms part of the GCSE specification. The manipulation of data to find an activation energy was more challenging in (c). The best candidates processed the data successfully, nearly always using the simple method of finding the difference in \ln rate and the difference in $1/T$. However, a significant number simply inputted a set of data into the expression, but then did not realise how to deal with the constant, c . A small number of

candidates, with high levels of numeracy, were able to put both sets of data into the Arrhenius equation, cancel out the constant and hence derive the activation energy. In (d) many candidates could deduce the order with respect to haemoglobin in (i). The increased demand of having to process a change in two variables to find the order with respect to carbon monoxide led to many candidates ignoring the change in haemoglobin concentration. Hence, the mark for the justification of first order tended to discriminate effectively at the higher boundaries. The allowance of transferred error marks in (iii) and (iv) allowed resilient candidates to gain credit, though surprisingly some candidates struggled to rearrange their equation to find k .

Question 7

Although the monomers may have been unfamiliar to many, the chemistry involved in the polymerisation reactions in (a) is relatively simple, and consistent with the GCSE specification. Hence it was disappointing to see many low scores. The most accessible marks were for linking the monomers to the type of polymerisation. Despite guidance in the stem of the question, few were able to construct equations for each reaction, though some were able to give the formulae of the repeat units. The most common error was showing the extension bonds on poly(cyclohexene) emanating from positions 1 and 4 on the carbon ring. Whilst many recognised the production of water in the condensation reaction, only a few, as demanded by the command word, contrasted this with the addition reaction. Most candidates were able to score at least a mark in (b), nearly always for the idea of recycling /reusing the polymers. A number framed their answer in the context of how chemists can limit the problems caused by polymer disposal, rather than the more sustainable use of the materials, demanded by the question.

Question 8

Candidates who approached this question in a systematic, logical fashion by determining the mass, moles and ratio of the three elements found this problem straightforward. However, many adopted a 'scattergun' approach based on finding the moles of carbon dioxide and water. Only a few such candidates then managed to determine the moles of carbon and hydrogen, and then found it difficult to use their work to find the mass or moles of oxygen. A number confused the mass of oxygen in Y with the mass of molecular oxygen involved in the combustion of Y.

Some candidates, who perhaps found the unstructured nature of (b) difficult, were able to look for amounts in moles to calculate, and scored the first mark. Even then, a number of candidates did not read the stem of the question with enough attention and used an incorrect volume for the sodium hydroxide solution. Others worked through the calculation with care,

with the most common omission being the realisation that a dicarboxylic acid has a 1:2 ratio with sodium hydroxide solution, leading to answer of 52 g mol^{-1} . The candidates who could find the molar mass of Y were often able to propose a correct structure, irrespective of their answer to (a).

Question 9

Completion of the table in (a) was attempted by nearly all candidates, though only a minority scored both marks. The calculation in (b) yielded marks for many, though not taking into account the overall yield of the process meant an answer of 622.5 g was common. Whilst many candidates could identify chiral carbon atoms in (c)(ii) a number seemed unable to work with skeletal formulae, circling whole sections of the molecule, covering several carbon atoms. Most candidates in (d) assigned the crystalline structure solely to hydrogen bonds rather than the formation of zwitterions.

Question 10

Many were able to construct the equation in (a)(i) correctly, but a number showed $\text{C}_4\text{H}_9\text{NH}_3^+\text{OH}^-$ as a single product. In previous series, the majority of candidates have been able to use ideas based around the electron density of an arene ring to explain differences in reactivity between phenol and benzene. In (a)(ii), use of a similar model could be used to explain the difference in basicity, and those who used this approach often scored two or three marks. The reagent in (b) was well known, though some candidates only scored one mark, by either using propanoic acid or by using an acyl chloride with an incorrect number of carbons. Whilst many recognised the reaction as nucleophilic substitution in (d)(ii), far fewer could construct the mechanism. Whilst some excellent answers were seen, others revealed little understanding of curly arrows, with contradictions such as arrows pointing to lone pairs or bonds evident.

Question 11

Most candidates could plot the graph accurately in (a), but for some candidates this was the extent of credit achieved. Interpreting the graph in (b) proved a challenge for many, with a significant number suggesting first order, perhaps confusing this graph with a rate against time graph. Of those who suggested 0 order most of the justifications said little more than 'the graph is a straight line' without linking their statement to the variables on each axis.

Transferred error marks were available in (c) and (d) and it was pleasing to see some candidates work logically through these items, despite getting the wrong order in (b). However, others didn't make the link to the type of nucleophilic substitution and classification of halogenoalkane, so did not score.

Question 12

Many candidates struggled to gain credit here, with a number seeming to not know where to start with this type of problem. Others were determined enough to try to apply their organic reaction knowledge, but rather than beginning with the lengthening of the carbon chain, they spent time trying to convert the -bromo group to an alcohol, nearly always using aqueous NaOH. Having formed an alcohol with five carbons some tried unfeasible reactions to insert alkyl groups, whilst others perhaps realised their error, but were unable to propose a solution. Of those who spotted the additional carbon atom, most used the reaction of the bromoalkene with potassium cyanide to extend the chain length.

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; text in bold is particularly important
- check calculations for minor errors such as unit conversion or inappropriate numbers of significant figures
- if unsure where to start in unstructured calculations look for amounts moles to calculate to get you going – ‘if in doubt, mole it out’
- plan your answer to free response questions by splitting your work into small sections, based on the question requirements given in the stem.
- ensure you can write equations for both types of polymerisation reaction
- practice drawing dot-and-cross diagrams for a range of molecules with dative covalent bonds
- practice a wide range of empirical formulae questions, following a systematic method of mass, moles, ratio. Make sure this includes problems based on combustion analysis data
- check synthesis questions with care to ascertain whether the target compound has more carbon atoms than the starting reagent. Don't be afraid to work backwards, from the target molecule back to the starting material. It is often easier to spot the single step needed to form the functional group in the target, than see the multiple steps to go from the starting material to the target.

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>

