Examiners' Report
Principal Examiner Feedback

October 2020

Pearson Edexcel Advanced GCE
In Chemitry (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

October 2020
Publications Code 9CH0_02_2010_ER
All the material in this publication is copyright
© Pearson Education Ltd 2020

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, can express their ideas clearly and carry out calculation, explaining their working.

Question 1

The vast majority of students could draw a dot-and-cross diagram to show the bonding in methanol. A few omitted the lone pairs on the oxygen atom so they scored 1 mark and a very small number tried to show ionic bonding. Many candidates realised that the O-H bond would have the shortest bond length, although a few lost the mark as they wrote C-O-H, showing two bonds. Almost all candidates knew that the strongest intermolecular attraction that occurs between methanol and water molecules is hydrogen bonding, but not all of them could draw a correct diagram to show this interaction. Some omitted the lone pair of electrons on oxygen, some of those who included the lone pair did not show the hydrogen bond starting from it, some omitted to show at least one correct dipole and some did not show the linear arrangement of atoms through the central hydrogen in the hydrogen bond. Some candidates drew more than one hydrogen bond and did not score a mark if there was an error, such as an incorrect bond angle, in one of them. A few candidates showed hydrogen bonding between two methanol molecules instead of between methanol and water.

Question 2

The majority of candidates knew that bromoethane is produced when ethene reacts with hydrogen bromide, although a few showed 1,2-dibromoethane. Many candidates did know that steam and an acid catalyst are needed to convert ethene into ethanol, however a significant number of candidates had not learnt this reaction. The structure of the polymer formed from but-1-ene was generally well-answered, with just a few candidates including a double bond, not showing the extension bonds or not showing two repeat units. The majority of candidates could calculate the number of molecules in 70.0 g of but-1-ene, with the most common errors being an incorrect molar mass' not converting mass into number of moles and dividing the number of moles by the Avogadro Constant.

Question 3

The vast majority of candidates gave the correct oxidation numbers of bromine in the three species. However, many of them stated the reaction was disproportionation, showing that they did not understand the meaning of this term. Disproportionation takes place when an element in a **single** species is simultaneously oxidised and reduced. In the reaction given, two different species of bromine are oxidised and reduced. The majority of candidates calculated the volume of oxygen in (b) correctly. Some used the mole ratio the wrong way around and some did not use it at all. A few tried to use the ideal gas equation, which was not needed here as the molar volume of gas was given and there was no change in temperature or pressure. It was disappointing to see some candidates dividing the number of moles of oxygen by the molar gas volume instead of multiplying them.

Question 4

It was pleasing to see many candidates scoring high marks for (b). Many candidates gave the three correct structures for **T**, **U** and **V** and most could explain their reasoning in terms of the reactions. A common error was to show **T** as butan-2-ol but to show **V** as the ester formed from butan-1-ol. A few candidates thought that butan-1-ol would be oxidised to butanal and then further oxidised to butanone. Some candidates thought that **V** was a carboxylic acid.

Question 5

Candidates found (d)(ii) to be a challenging question. This type of calculation was unfamiliar to the majority of candidates and many struggled to start it as they did not realise that the carbon dioxide would be removed by aqueous sodium hydroxide so the volume of carbon dioxide was 125 cm^3 and the value of x was 5. The unfamiliar mechanism in (e) was clearly drawn by the majority of candidates. Common errors included: showing the formation of the minor product instead of the major product, giving an incorrect dipole on ICl and not starting a curly arrow from a bond or a lone pair of electrons. The vast majority of candidates scored a mark for calculating the number of moles of bromine used in (f). Some candidates did not realise that 2 mol of bromine are needed to react with 1 mol limonene as there are two double covalent bonds, some candidates were unable to calculate the correct molar mass of limonene. Candidates were able to score a transferred error mark for the final percentage, provided the answer was less than 100 %. However, some candidates calculated a mass of limonene that was greater than 0.500 g so reversed the fraction to give a percentage that was less than 100 % and this was not given credit. Candidates who calculate a percentage greater than 100 should go back and check their working to see where they have made an error.

Question 6

It was surprising that only a minority of candidates knew that ethanolic sodium hydroxide reacts with halogenoalkanes to produce an alkene in an elimination reaction. The vast majority of candidates could plot a correct graph in (b), with just a few omitting to label the axes or plotting time on the y axis. Many candidates were confused about the half-life of a reaction and they would benefit from more experience in working these out from graphs of first order reactions. The vast majority deduced that the reaction was zero order with respect to hydroxide ions in (d)(i) but many were unable to use this to give the S_N1 mechanism for the reaction between RBr and hydroxide ions. Many candidates showed the S_N2 mechanism even though the kinetics showed that hydroxide ions are not involved in the rate determining step. Some candidates showed a hybrid of S_N1 and S_N2 and many omitted to show the bromide ions formed. It was pleasing to see many candidates giving a clear explanation why the product of the reaction is not optically active. The most common cause of a mark loss was not stating that the intermediate is planar around the positive carbon.

Question 7

Many candidates realised that hydride ions would be repelled by the high electron density of the double bond in an alkene or knew that alkenes react by electrophilic addition and hydride ions are nucleophiles. There were many correct answers giving a suitable reagent and condition, but some candidates had not learnt the basic reagents and conditions for the organic chemistry reactions in the specification. Only a minority of candidates knew that potassium cyanide in ethanol react with halogenoalkanes to form nitriles. Unfortunately a few candidates lost this mark as they did not give a specific halogenoalkane, for example, 1-bromobutane. The majority of candidates knew that an acid needs to be added to the salt to form pentanoic acid. There were many excellent answers to the synthetic route in (b) showing those students had practised this style of question and they knew the organic chemistry reactions. Candidates should realise that they need to make a Grignard reagent from a halogenocompound so should start by forming bromobenzene. Some candidates knew that they needed benzoic acid to react with phosphorus(V) chloride to form benzoyl chloride and they received credit for this.

Question 8

Many candidates identified the alkene and carboxylic acid functional groups in **X** but some just showed C=O and OH. The deduction of the skeletal formula of **X** was done well by many but some did not read the question and lost the mark by drawing a displayed formula. Some candidates ignored the information given about **X** and drew a branched chain or a compound that would exhibit geometrical isomerism. Some candidates have a clear understanding of ^{13}C NMR and ^{1}H NMR spectroscopy and constructed concise, logical, well-explained answers to the extended writing question in (b). There was a space before the writing lines and the most successful candidates used that to draw the displayed formulae of propan-1-ol and propan-2-ol and many of them annotated those formulae to help with their answers. There were many answers that jumped from one structure to another and one type of spectroscopy to the other without making it clear which was being discussed. This question asked candidates to compare the NMR spectra so they must include at least one similarity and one difference between them. Some candidates just wrote about the spectra and did not make the similarity of the OH proton clear. Some candidates seemed unsure what to do about the OH proton and either ignored it or did not realise that the ^{1}H NMR spectrum would just have a singlet peak as it is not split and does not cause splitting. A few candidates included chemical shift values, even though they were told they were not needed and there was no credit for them. A few candidates were not clear on analytical techniques and wrote about mass spectrometry or infrared spectroscopy. The majority of candidates would benefit from more work on both types of NMR spectroscopy and more practise in answering ‘compare’ style extended writing questions.

Question 9

Most candidates knew the label for the vertical axis in the Maxwell-Boltzmann distribution. Many could draw a second curve to show the same gas at a lower temperature, although some showed it curving up at the end or crossing the x axis or the curve for T_1. Many knew that the molecules would have a lower kinetic energy at a lower temperature but not all related this to a lower proportion of molecules having less energy than the activation energy. The majority were able to label a suitable value for the activation energy with a catalyst on the diagram. Many candidates were able to substitute the values correctly into the expression, rearrange it, evaluate it to find the activation energy and give their answer to an appropriate number of significant figures with correct units. Some candidates did not read the table of data correctly and mixed up the values for temperature and the rate constant. Some candidates were unable to calculate $\ln(k_2/k_1)$ and / or $(1/T_2 - 1/T_1)$ and some were unable to rearrange the equation. Some candidates carried out the calculation correctly but lost the final mark as they gave 4 or more significant figures in their answer (even though the data was all given to 2 significant figures) or they gave incorrect or incomplete units, such as just kJ instead of kJ mol^{-1}.

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
- make sure that comparisons are made when required and include similarities and difference
- learn the reagents and conditions for the organic reactions in the specification
- 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
- reread questions and answers, where time permits, to avoid 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

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom