A-LEVEL
CHEMISTRY

7405/2 Paper 2: Organic and Physical Chemistry
Report on the Examination

7405
June 2019

Version: 1.0

General Comments

Question 5 on this paper was withdrawn from marking because of an unfortunate printing error, for which AQA apologises. The error occurred in the Arrhenius equation in line two of the question where an italic upper case I (*I*) was printed instead of a forward slash (/).

Although this was noticed by only a very small number of students, and seems to have affected even fewer, all students were awarded all four marks for the question in order to ensure that no students were disadvantaged in any way.

Despite this, the paper discriminated well with the marks ranging from 101 to 4. The mean was up by 1.9 marks compared to 2018 but the standard deviation was down by 0.4. Both of these changes are partly due to the four-mark boost which affected students at the lower end much more than at the higher.

Students also found it easier to gain marks in Question 7 which was marked by levels of response than in the equivalent levels of response question in 2018.

Other questions were of similar difficulty although the penalty for a chemical error was only one mark, so that students did not miss out on more than one mark for one error. Some mechanisms also involved completion of a mechanism, rather than writing the whole thing. This enables the examiners to test more mechanisms in the paper without using an excessive number of marks on this area of the specification.

Question 1

01.1 This question was found to be quite demanding and relatively few students were able to balance the equation correctly. Common errors were to use molecular formulae and to give HBr as the second product.

01.2 The mechanism was answered well although some students drew an intermediate with too few carbons. The structure of a cyclic secondary amine proved difficult for some to deduce and many incorrect hexagons or primary amine structures were drawn.

01.3 KCN was usually given but the correct aqueous-alcoholic conditions were rarely seen. The mark for hydrogen and nickel was gained by most.

01.4 A third of the students gained both marks. The inductive effect was well known and expressed accurately, but fewer referred to the lone pair of electrons on the nitrogen atom correctly.

01.5 This part was answered well by most students.

Question 2

02.1 Most of this question was based on Required Practical Activity 5 example (a), from the Practical Handbook. Sadly, this experimental procedure did not seem familiar to many students and few completed the diagram correctly.

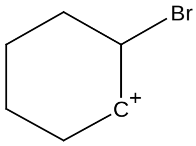
02.2 & 3 Only the more able students knew that cyclohexene is immiscible with water and is a clear liquid when dry.

02.4 The calculation was answered well and over half of the students scored full marks. Others confused mass and volume or could not correctly rearrange the expression for density.

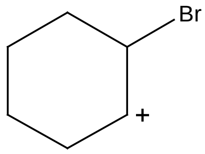
02.5 The mechanism was usually answered well although the cyclic nature of the alkene confused several students who wrongly drew a substitution mechanism instead of electrophilic addition.

Students should be advised not to mix skeletal and structural formula types at a carbon. The intermediate carbocation in part five should **not** be written as structure **A** below. Correct possibilities are structure **B** (preferred) or structure **C**. Once a carbon atom is labelled as such, it must have the correct bonding as in **C** but not **A**.

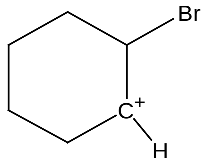
A



B



C



Question 3

03.1 The calculation was generally well done and most students gained at least the first two marks. A common error thereafter was to convert the 1:1.6 ratio into 2:3 which meant that no further marks were gained. Those who deduced the correct whole number ratio as 5:8 usually drew a correct branched structure, although some failed to gain this final mark by drawing a non-branched diene.

03.2 Over half the students drew a correct structure but only a very small number could give its correct IUPAC name as buta-1,3-diene.

03.3 Despite the unfamiliarity of this polymer, students answered part 3 well, especially the explanation. The most common mistakes in the structure were to show trailing bonds from the H atoms or to omit trailing bonds altogether.

03.4 Although there were many successful answers to this final part, a large proportion of the other attempts were too general to score and did not specify that it was the C−C bonds that were non-polar or too strong to be hydrolysed.

Question 4

04.1 & 2 Although the results of the kinetics experiments were given in a different way from usual, the first two parts of this question were answered well and many students scored full marks.

04.3 Most students were able to calculate the rate constant, *k*, and to deduce its units correctly although others struggled to rearrange the rate equation.

Question 6

06.1 The first part of this question was well answered. Acidified potassium dichromate was the usual oxidising agent, although the ‘acidified’ was sometimes omitted so that the first mark was not gained. The question asked for ‘a test-tube reaction’ − singular − so that students who used two reagents, often Tollens’ after the acidified dichromate, and gave the final observation, failed to gain the marks.

Students have been advised for many years not to use the phrase ‘no observation’ when asked to give experimental observations. This advice appears in the introduction to the mark schemes for all AQA chemistry papers, but unfortunately is still being ignored.

06.2 Structure **A** was found easier to deduce than the branched structure **B** and only the more able students gained both marks.

06.3 Similarly, this part was answered well by only the most able students. Many did not realise that **C** and **D** were aromatic compounds.

06.4 Only the least able students did not gain the mark in this part.

Question 7

07.1 Many students struggled to name organic compounds in this paper correctly and the first part of this question was no exception. The incorrect naming of X indicated a general failure to observe the IUPAC rules for naming ketones and/or the cyclic nature of the compound.

07.2 Overall, this question was well answered and approximately two-thirds of the students gained four or more marks. Some students stumbled in their explanations of the boiling point differences (Stage 1) and were therefore limited to level 2. Most students dealt with the characteristic observations from ^{13}C NMR and IR spectroscopy (Stages 2 and 3) without much difficulty.

For stage 1, most students correctly stated that compound Y has the higher boiling point. Explanations with reference to hydrogen bonding and permanent dipole-dipole forces in Y and X, respectively, sometimes fell short when there was a failure to mention the intermolecular nature of these forces. Typically students recovered the potential loss of a marking point by referring to the fact that more energy is required to overcome the H-bonds. Full and unnecessary discussions on how the two types of intermolecular forces arise were common, as was the discussion of (fractional) distillation of a mixture of the two liquids.

Most students were able to report on the correct ranges of chemical shifts in ^{13}C NMR spectra for both compounds. Some effective responses recognised three peaks for each compound, with detailed and comprehensive analyses of the types of carbon involved.

Communication on IR spectra was generally good, with students correctly identifying absorptions and corresponding bond types. There was some use of non-technical language such as ‘dips and troughs’ to communicate absorption or low transmittance. Reference to the unique fingerprint regions appeared in very few responses.

Question 8

08.1 The mechanism in part 1 was well known.

08.2 Only a third of students gained this mark. Many failed to balance the equation correctly whilst others were unable to identify either the other reactant which could have been given as 6[H] or $3H_2$, or the other product as water.

08.3 This part was generally answered well and many students scored both marks. Some, however, failed to gain the second mark because of careless drawing of curly arrows or for showing a chloride ion removing a proton from the intermediate.

08.4 This part was well answered.

08.5 This part proved to be difficult and few gained the mark here, including about a fifth of the students who made no attempt whatsoever.

08.6 Many students could not deduce the formula of ammonium ethanoate, often giving the formula of ethanamide instead. Sadly, of those who did write CH_3COONH_4 correctly, some then failed to balance the equation with $2H_2O$.

08.7 The relatively straightforward calculation in this part was done well by the majority of students. A surprising number were unable to calculate the correct M_r of paracetamol from its structural formula, but they could gain credit consequentially for calculating a mass of hydroquinone.

Question 9

09.1 The use of concentrated hydrochloric acid to hydrolyse a protein was known by relatively few.

09.2 By contrast, in part 2, most knew how to locate the spots on a TLC using ninhydrin or UV light.

09.3 The number of amino acids, as shown by the seven dark spots on the chromatogram, was answered correctly by under a quarter of students.

09.4 Answers in part 4 were poorly explained, with many students simply stating that the amino acids had different solubilities or different R_f values in different solvents without explaining that some had the same R_f value in solvent 1 hence the need to use solvent 2.

Question 10

10.1 Approximately 60% of students deduced a correct molecular formula in part 1. The most common error was leaving the answer as a structural formula, so failing to gain the final mark.

10.2 The question in part 2 was fairly accessible, with about a third of students gaining full marks. The most common error was using the wrong ratio (usually either 1:1 or 1:2 the wrong way round), thereby failing to gain a mark. Only a few failed to give the answer to three significant figures.

10.3 Three-quarters of students deduced the correct number of peaks in this part.

10.4 Only a third of the students were able to draw the correct structure for the diol.

10.5 This part was answered poorly. A very common error was to discuss fragmentation − a topic which is not required in this specification. Many muddled significant figures and decimal places and failed to say that when measured to several decimal places the relative molecular masses of the diols and the acid are different.

Question 11

11.1 The first part of this question was fairly well answered. The structure of the ester was usually correct but the other product, propanoic acid, was often missing or given as ethanoic acid or water. Ethyl ethanoate was a common wrong answer for the name of the ester.

11.2 Part 2 was challenging and almost a quarter of students made no attempt to answer the question. The left hand (glycerol) part of the molecule was better known. Some students miscounted the carbon atoms in the acid part by including the methyl group of the biodiesel in the oil. Another common mistake was to draw the COO linkage the wrong way round.

11.3 Part 3 was also found difficult; just over a sixth of students made no attempt and fewer than that number scored two marks. The position of the double bonds in the skeleton was more often correct than the Z stereochemistry. Sadly, a few students failed to gain a mark by showing H atoms in their otherwise skeletal formula.

11.4 The non-integral moles of oxygen, coupled with the fact that there are two oxygen atoms in the structure of the ester, made this question a good discriminator. The main error was to write 27½ mol of oxygen, forgetting the two oxygen atoms in the ester molecule.

11.5 Most students answered this part correctly although some mentioned the C−O 1000−1300 cm^{-1} range rather than the expected range for C=O, 1680−1750 cm^{-1}.

11.6 This part was badly answered and many students gained neither mark. Wrong answers included reference to ultraviolet light and ozone as common themes. Common errors were not mentioning that the (vibrating) <u>bonds</u> in CO_2 are responsible for absorbtion of infrared radiation. Very few students mentioned infrared radiation being emitted by the Earth. A common misconception is that global warming is caused by the destruction of the ozone layer.

Question 12

12.1 The way that the DNA strands had been presented helped many students to score both marks in the first part of the question. Those who did make mistakes usually added extra hydrogen bonds, thereby failing to gain at least one of the marks they might otherwise have gained.

12.2 A reasonable number of students scored at least one mark by identifying the correct base and sugar in the cytosine nucleotide. Fewer identified the correct phosphate group and instead selected the alternative on C3 of the sugar ring.

12.3 This part was very well known to students and many scored the mark by simply identifying the correct base pairs that lead to the complementary arrangement of DNA strands.

Question 13

13.1 This question discriminated well. It was surprising to see how many students were unable to draw the correct structure of 2-methylbutanal. Many placed the methyl group on carbon 3. Most students were familiar with the mechanism and drew the

2 arrows correctly. A few failed to gain the mark as they did not draw a lone pair on the hydride ion.

The explanation was well attempted by most students, but few scored all three marks as they did not explain how the nucleophile is attracted to the $\delta+$ carbon of the carbonyl group but is repelled by the electron rich C=C bond.

13.2 Nearly two-thirds of students scored both marks in this question. A common incorrect answer was to suggest acidified potassium dichromate as the reagent when it would not, of course, distinguish between the aldehyde and the alcohol formed.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.