AQA

ASLEVEL
CHEMISTRY

7404/2 Organic and Physical Chemistry
Report on the Examination

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General Comments

Examiners were pleased with the overall performance of students in this examination. There are, however, some key points about students' performance that may prove to be useful for teachers going forward.

- There was some evidence that students' knowledge did not include the whole of the specification and, in particular, items that were not on the previous specification.
- Students did not always show full working in calculations. In some cases the correct answer may not score any marks unless the specific steps in the working are shown. In many calculations these steps are each awarded a mark. In such questions, students are instructed to 'Show your working'.
- Students were not always able to deduce the appropriate number of significant figures to which to give their answers.
- A significant number of students were not able to convert between common units (e.g. mg to g, cm^3 to m^3, cm^3 to dm^3, kPa to Pa, etc.).
- Some students were unable to calculate apparatus uncertainties, in particular to consider whether there are one or two uncertainties, for example when a change in temperature or mass is found. Perhaps students would benefit from more practice with this skill when reporting on their quantitative practical work.
- A common theme was that some students failed to understand **why** they carry out the procedures that they do in practical work, rather than just knowing what to do.
- In this examination, weaker students did not appreciate that covalent bonds do **not** break when molecular substances, including thermosoftening polymers, melt.
- Many students were careless in their use of language when discussing the nature of, and breaking of, hydrogen bonds – too often answers read as though a hydrogen bond is a covalent bond within a molecule rather than a force between molecules.
- Many students did not understand the difference between structural isomers and stereoisomers.
- In questions requiring longer answers, many students need to structure their answers more logically, including the use of paragraphs.

Question 1 Maxwell–Boltzmann distribution

01.1 This was a straightforward mark which most students scored.

01.2 Most students knew that the distribution shifted to the right and the peak lowered, but many failed to draw their distribution so that the area under the curve remained the same to show that the number of molecules was unchanged.

01.3 Many students could explain that more particles had the required activation energy at higher temperatures, but only the best students explained that this increased the frequency of successful collisions, with many simply referring to the chance or number of successful collisions rather than the frequency.

Question 2 Quantitative analysis of hydrocarbons

02.1 Most students made some progress with this calculation to find the M_r of a volatile hydrocarbon, but few scored full marks. Key problems were incorrect rearrangement of the ideal gas equation, incorrect unit conversions for volume (from cm^3 to m^3), pressure (from kPa to Pa) and mass (from mg to g). In this question, working was required and each step in the calculation was marked separately. This meant that students who got the correct

answer without working, or with incorrect working, were penalised. Some students, who arrived at a correct final value, scored zero marks as they made multiple very significant errors that, by chance, cancelled out. In addition, many students failed to give the final answer to two significant figures (which was based on the gas volume – given as 72 cm^3).

02.2 Most students started this question correctly but struggled to convert the ratio 6.975:16.3 to 3:7, with 7:16 and 1:2 being common errors, and so failed to deduce the empirical formula. Some students still managed to deduce the molecular formula using the M_r alone. Again, students could not score full marks on this question without showing full working.

Question 3 Qualitative analysis of hydrocarbons

03.1 Most students made good progress with this question, with many identifying one or more of the three compounds. However, few scored full marks as they did not explain how they deduced the structures. Many did not explain the significance of the results of the tests with bromine water. The meaning of the term stereoisomers was not well known, and often confused with structural isomers; few referred to the restricted rotation around the C=C bond leading to stereoisomers in molecules where both of the C atoms in the C=C bond have two different groups attached. Some students incorrectly suggested that alkenes that do not have stereoisomers have free rotation around the C=C bond.

Question 4 Combustion of alkanes

04.1 Most students could write the equation for the complete combustion of propane.

04.2 This question required students to rearrange a mathematical expression, but many could not do this because they made errors with minus signs on rearrangement.

04.3 Very few students appreciated that bond enthalpies are measured in the gaseous state and so the expression would not give an accurate value for a liquid alkane.

04.4 Most students plotted the points on the graph correctly, but a very significant proportion of them drew a best fit line that was straight rather than a curve. Most students read the value for propane off the graph, but some did not include the negative sign to show it was exothermic. Worryingly, some students did not know how many C atoms the alkanes contained and failed to score.

04.5 Many students failed to find the mass of 1 dm^3 of isooctane, not appreciating that the density value given was in g cm^{-3} rather than g dm^{-3}. Some students lost the second mark because they did not appreciate that the answer should be given to three significant figures.

Question 5 Titration of ethanedioic acid

05.1 Most students made good progress with the calculation to find the mass (in mg) of ethanedioic acid dissolved.

05.2 This question highlighted the need for students to understand the practical procedures they carry out. Only a minority could explain that the walls of the conical flask are washed down to ensure all the reactants are washed into the reaction mixture.

05.3 The meaning of the term concordant titres was reasonably well known, but only a minority of students knew that titres should be within 0.1 cm^3 of each other.

Question 6 Reactions of halogenoalkanes

06.1 This straightforward nucleophilic substitution mechanism was well known and well drawn in general.

06.2 This yield calculation proved to be challenging, with the combined use of the volume and density of the starting material proving to be beyond many students.

06.3 Most students knew that an elimination reaction took place, but few could give the correct name for the product, methylpropene.

Question 7 Dehydration of alcohols

07.1 The first use of a mechanism with skeletal structures proved to be challenging for many students, even with the framework provided.

07.2 While this was challenging, many students could work out the structure of the alternative product.

07.3 Many students realised that this question referred to the relative stability of carbocations, with the best students referring to the extra stability of tertiary carbocation **E** relative to secondary carbocation **D**. Students' explanations were often confused and it was not always clear to which carbocation they were referring.

07.4 This was a very challenging question and only the best students could deduce the structure.

07.5 This question showed students' confusion between covalent bonds within molecules and the forces between molecules, and their poor understanding that covalent bonds do not break when molecular substances change state. Other students failed to refer to hydrogen bonds and van der Waals' forces acting between molecules. Some students focused on the practical procedure to separate the cyclohexene rather than on how the strength of the intermolecular forces affected the boiling points – it is important to answer the specific question that is asked.

Question 8 Organic molecules

08.1 This straightforward question was not answered well. Many students drew 2-methylbutanal rather than 3-methylbutanal, not appreciating that the C atom in the aldehyde group is carbon-1.

08.2 Many students drew the displayed structure of the correct product, thereby demonstrating their understanding of the identity of the major product of this addition reaction of hydrogen bromide to the alkene.

08.3 Most students realised that thermal cracking produced an alkene.

Question 9 Polymers

09.1 Many students believed incorrectly that covalent bonds break when PVC melts and failed to score on this question.

09.2 This question required students to know how many hydrogen atoms were on each carbon atom in a skeletal structure, but many struggled to count them correctly.

09.3 Very few students appeared to know why plasticisers are added to some polymers. This is new content for this specification.

09.4 This question required students to draw the displayed structure of a repeating unit and proved to be challenging.

Question 10 Reading a burette

Most students (77%) read the burette correctly, but a significant number read the scale upside-down to get 25.70 cm^3 rather than 24.30 cm^3.

Question 11 Apparatus uncertainty

Students struggled with this question (30.2% correct). Many did not appreciate that there are two uncertainties as two readings of the balance are taken to find a change in mass. Many did not realise that the uncertainty is with the mass of the solute itself.

Question 12 Infra-red spectrum

Many students thought the spectrum represented a carboxylic acid rather than a ketone, even though there is no sign of an acid O-H peak at all. 42.3% of students gained the mark.

Question 13 Bond angles

Many students (45%) could suggest the most likely bond angle around the oxygen atom in ethanol.

Question 14 Isomers

Many students (48%) got this correct, but many incorrectly thought that *E*-but-2-ene is a structural isomer of *Z*-but-2-ene.

Question 15 Propagation step in free radical substitution reaction

This was answered well with a high proportion of the students (68.8%) scoring the mark.

Question 16 Relative rate of reaction of halogenoalkanes

Many students (58.4%) got this question correct but many incorrectly believed that the fluoroalkane would react fastest.

Question 17 Reactions of alcohols

A good number of students (41.3%) could work out which alcohol could be oxidised but not dehydrated, but many could not – possibly due to a lack of appreciation of the need for the presence of a hydrogen atom on the carbon atom adjacent to the carbon with the alcohol group.

Question 18 Number of structural isomers

A minority of students (31.9%) scored this mark, with many incorrectly thinking there were one more or one fewer isomers than there actually were. Students are encouraged to take a systematic approach to deducing all possible structures.

Question 19 Number of molecules

Students found this question challenging (38.8% correct), possibly from a lack of familiarity with using the Avogadro constant.

Question 20 Precise molecular mass

Students also found this question challenging (41.8% correct), with many failing to appreciate that only one molecule did not contain any oxygen and so must have a different value from the others.

Question 21 Moles at equilibrium

This question was also a challenge to many students (42.1% correct) and they are urged to take a systematic approach to deducing the amount in moles of species present in an equilibrium mixture.

Question 22 Dilution of a solution

Nearly half of the students (44.8%) could do this, but many could not work out how much water to add to a solution to dilute it by a specific factor.

Question 23 Gas volumes

A good proportion of students (43.8%) could do this, but many may not have appreciated that the two identical flasks at the same temperature and pressure will contain the same number of gaseous molecules.

Question 24 Elemental analysis

There was no evidence that students were short of time on this calculation at the end of the paper and a good number (41.8%) completed it successfully.

Use of statistics

Statistics used in this report may be taken from incomplete processing data. However, this data still gives a true account of how students have performed for each question.

Mark Ranges and Award of Grades

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