AQA

A-LEVEL
CHEMISTRY

7405/2 Organic and Physical Chemistry
Report on the Examination

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Question 1 Required Practical Activity 7

01.1 This unfamiliar practical question proved difficult and relatively few students scored the mark for an appreciation that the narrow neck of a conical flask will reduce the loss of droplets of liquid in a reaction giving effervescence.

01.2 It was expected that students would draw a tangent to the curve at 2 minutes and use this to calculate the rate via their gradient. Most were able to score at least 2 marks here but a significant number struggled to present the units in the appropriate form of g min^{-1}.

01.3 The question required students to sketch a curve and most did this well. Marks 2 and 3 proved much more difficult and many students were unable to identify clearly the electron withdrawing effect of the $-CH_2Cl$ group and the way this weakens the O-H bond.

Question 2 Rates

02.1 Around 67% of students scored all three marks although a large proportion did so via the less efficient method of using the data from experiment 1 to calculate a *k* value. Despite being straight-forward the question discriminated well.

02.2 This question was reasonably well answered. The mark scheme allowed some weaker students to gain a mark for M2 by stating that the rate determining step is the ‘slowest step’.

Question 3 Reaction mechanisms

03.1 As with the other two parts of this question, the discrimination index of more than 0.65 showed that this type of question discriminates very well. Able students often scored all four marks for this familiar mechanism despite the unusual way the question demanded that students work backwards from the given intermediate for the first three marks.

03.2 Fewer students scored full marks here than with the other two parts of Question 3. Curly arrows were often poorly drawn and failed to show the formation of a bond between a C in the methylbenzene and the N in the electrophile $^+NO_2$.

03.3 Despite the less familiar use of a skeletal formula for propanone, this question was well answered with around 48% of students scoring all four marks.

Question 4 Synthesis, nomenclature, isomerism, electrophilic addition and intermolecular forces

04.1 This nomenclature question was quite well answered with almost half scoring the mark. Since this was an IUPAC name, key spelling errors were penalised; eg, the e in 3-bromopropan<u>e</u>nitrile was essential.

04.2 This was the levels of response question and the vast majority of students were able to get started, and access levels 1 or 2 by showing good knowledge of the electrophilic addition mechanism. Some students struggled because they did not show the mechanistic steps using curly arrows. The indicative content did allow for this and students could describe aspects of the mechanism in words, but it was much easier to do this via diagrams showing structures.
Level 3 proved much more difficult, with many failing to recognise that optical isomers were possible as a result of attack on the planar secondary carbocation from above or below the plane.

04.3 Despite being set on several occasions in the past, the use of aqueous ethanol as the solvent condition for this reaction was not well known and few students scored M2 here.

04.4 The reagent and condition mark was scored by large numbers of students but the equation proved far more difficult and only just over a quarter scored full marks here. The question had a high discrimination index and identified the best students.

04.5 Many were able to deduce the value of x as 5 but far fewer were able to work out that y was 9 because the functional groups at each end of this molecule had not reacted to produce a water molecule.

04.6 This question discriminated well. Despite several previous questions that required students to draw hydrogen bonds, a surprising number failed to show the lone pair of electrons involved in each H bond. The mark scheme allowed students to score full marks for H bonds between adjacent N-H groups, despite the fact that the H bonds in this case would be between adjacent C=O: and H-N groups. The linearity of the H bond and the single covalent bond from H to N was better known than in similar previous questions.

Question 5 Structure Determination

05.1 This was a very simple question requiring simple reference to the data sheet and so large numbers of students were able to score the mark.

05.2 Although straightforward, only about two-thirds of students were able to link the seven peaks on the ^{13}C NMR spectrum to the seven carbon environments in the molecule.

05.3 This was well answered but some students failed to identify the fact that the carbon giving rise to the peak concerned was part of an ester group.

05.4 This question discriminated very well with only the best students scoring full marks. That said, over half scored at least three of the five marks available.

05.5 Over two-thirds of students scored the mark for this question, despite not always being convincing in the way they showed there were three equivalent H atoms next to a carbonyl group. It is best practice to include the symbol for hydrogen (H) at the end of each line representing a bond from carbon.

05.6 This question was well answered and there were several alternative ways students could approach the question. Most focused on the lack of integration data on the spectrum but fewer gave the anticipated response about the peaks at δ=2.60 and 2.58 overlapping and making the splitting patterns difficult to interpret.

05.7 Only the most able students were able to draw together all the information from the spectra and data table to deduce the final structure. The question had a high discrimination index.

Question 6 Required Practical Activity 6

06.1 Around 69% of students scored here, showing that the requirement to acidify potassium dichromate(VI) with sulfuric acid was well known.

06.2 Around three-quarters of students were able to score at least 1 mark here. Some failed to score because, due to poor expression, they were unable to show clearly that the gas should be bubbled through limewater, or that simply observing effervescence would be enough to complete the test correctly.

06.3 This question on familiar organic tests was answered quite well with around 80% able to score at least half marks. The observations for M2, M4, M6 and M8 were very well known, but the substances that would react in each test were less well understood. The question had a high discrimination index.

06.4 Relatively few students were able to identify S in the diagram as a fractionating column. The direction of flow for the water in the condenser was much better known. The explanation that fractional distillation is preferred to simple distillation in this case because liquids K and M were likely to have similar boiling points was not well answered.

Question 7 Calculations involving gas volumes

07.1 This question was very well answered despite the unfamiliar context and around 75% scored all four marks. Common mistakes included a failure to convert the temperature and pressure into the appropriate units for use in the ideal gas equation. Some students were also unable to convert their calculated volume into a value in cm^3.

07.2 This question was also well answered but most took the less efficient route to the answer by using $pV = nRT$ again rather than applying the temperature ratio to their answer in Question 7.1.

07.3 This question proved to be more demanding than similar questions in the past because students were required to work out not only the percentage uncertainty in the mass but then to apply this to find the resulting uncertainty in the volume calculated.

07.4 This question was poorly answered and few took the correct approach, using the gas molar/volume ratios from the stoichiometry in the equation, to deduce the volume of CO_2 produced and the volume of O_2 left. Large numbers tried to use $pV = nRT$ again and, although this approach could have worked, it was likely that errors would be made because of the number of steps required.

Question 8 Ester hydrolysis and calorimetry/bond enthalpy calculations

08.1 This question was reasonably well answered with many scoring for the structure of glycerol but far fewer gaining the mark for deducing that 3 mol of carboxylic acid would be needed to balance the equation.

08.2 Weaker students were often able to get started with this extended but familiar style of calculation based on a calorimetry experiment. That said, the question had a high discrimination index showing that only the better students were able to score full marks. A common mistake was to use the mass of the acid in the $Q = mc\Delta T$ step in the calculation, rather than the mass of water. Some lost the final mark either for failing to give the answer to 3 significant figures or failing to show that it was exothermic by including a negative sign for their final answer.

08.3 This was generally well answered.

08.4 A surprisingly significant number of students missed the fact that they were required to calculate the percentage of sulfur present in the substance before calculation of the empirical formula. These students were still able to access the other 2 marks but, as a result, only around 50% scored all three marks for this simple calculation.

08.5 Acid rain and SO_2 were well known and a large number of students scored both marks here.

08.6 The most common issue with the answers to this question was the failure to show sufficient workings. Better students showed values for the sums of the bond enthalpies for bonds broken and bonds formed. Even if a mistake was made in these values the final mark could be scored consequentially for their correct use in calculating the approximate value for the enthalpy change. Over 70% were able to score at least one of the three marks available.

08.7 This question was generally well answered. The most common mistake was for an incorrect arrow direction in a Hess's law cycle, resulting in a negative answer. Other mistakes included a failure to use the stoichiometry values from the given equation to multiply the enthalpies of formation by the correct factors.

Question 9 Organic mechanisms, use of the Arrhenius equation and Maxwell–Boltzmann distribution

09.1 This was a very unfamiliar homologous series and few students were able to deduce a valid general formula.

09.2 This question discriminated well and the best students were able to apply the ideas understood from more familiar mechanisms to the structures given.

09.3 This question required students to demonstrate their understanding that the Arrhenius equation could be rearranged to find the temperature for this reaction. Over half were able to score at least two of the three marks. The most common mistake was a failure to convert the activation energy given into a value in J mol^{-1}.

09.4 This straightforward question about the Maxwell–Boltzmann distribution was surprisingly poorly answered by many. Most were able to get started but the high discrimination index showed that only the best students scored four or five marks here. Common errors included getting the axes labels the wrong way around along with a failure to show, in the sketch graphs, how the increase in temperature affects the distribution of energies in a sample.

Mark Ranges and Award of Grades

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