



AS

Chemistry

7404/2 – Organic and Physical Chemistry

Report on the examination

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General

This examination of the AS specification highlighted some key points about students' performance that may prove useful.

- Students should take care to lay out their calculations in a stepwise manner and clearly state what each line of working represents. Many students have a jumbled mess of numbers that do not follow on from each other.
- Students struggle on questions that test understanding of practical work, especially organic preparations. Students need to understand why they do what they do in a practical rather than simply following a series of steps.
- Students are improving at mechanisms, including ones which are unfamiliar, but precision in drawing the arrow when a bond breaks is a key area to address. This includes the direction of the arrow as well as where it starts and ends (e.g. breaking O-H in an $^+\text{OH}_2$ group attached to a C or N-H in an $^+\text{NH}_3$ group attached to a C)

Q1 Reactions of halogenoalkanes

- 1.1 This question looked at why halogenoalkanes react with nucleophiles. Few students referred to the C of the C-halogen bond being δ^+ with many just stating that the bond was polar. Many students failed to mention that nucleophiles have a lone pair of electrons and that this is attracted to the δ^+ C atom in the C-halogen bond.
- 1.2 Students had to complete a nucleophilic substitution mechanism. Many did it well including a few who did an SN1 rather than SN2 mechanism. Common errors were putting a minus charge on NH_3 or showing incorrect breaking of the N-H bond in the last step.
- 1.3 Students were asked to identify the solvent that is used in order for a substitution reaction to occur. A minority gave the correct answer water, with many stating alcohol/ethanol with many others giving reagents (rather than solvents) that would lead to other reactions. Many students did not seem to understand how changing the solvent affects the reaction with hydroxide ions.
- 1.4 Students had to complete an elimination mechanism. Many did this well although some gave the mechanism to form but-2-ene rather than but-1-ene as required. Few students appreciated that the two other alkenes were *E*-but-2-ene and *Z*-but-2-ene with most going for but-2-ene and some other compound that was commonly not even an alkene.
- 1.5 The question asked about the bond angle around the positive C atom in a carbocation. Students struggled with many assuming there was a tetrahedral shape rather than a trigonal planar shape with 120° bond angle.
- 1.6 Students often had the idea of what a co-ordinate bond actually is but few were precise in their language to state from where and to where the lone pair was donated.

Q2 Methanol

- 2.1 This question was very well answered with students having to explain how a catalyst increases the rate of reaction.
- 2.2 Students did well in explaining how an increase in temperature increases rate of reaction.
- 2.3 Students were asked to draw the hydrogen bond between two methanol molecules. Many made good progress but a large number of students had the atoms in methanol bonded O-H-C rather than H-O-C and others attempted to form a hydrogen bond to an H atom on the C.

Q3 Intermolecular forces

Students had to explain the shape of two organic molecules, deduce whether each molecule was polar and then explain their relative boiling points. This question was answered well on the whole with most students appreciating that CCl_4 is non-polar while CHCl_3 is polar, although fewer could explain this by discussing whether dipoles cancel out or not. Most students could identify the intermolecular forces and could justify why CCl_4 has stronger intermolecular forces despite not having any dipole-dipole forces in the way that CHCl_3 does. A few students thought that covalent bonds were broken when these compounds boil.

Q4 Identifying compounds

- 4.1 Students struggled to identify these two compounds, with many not appreciating that they were both carboxylic acids.
- 4.2 Students struggled to identify this compound, with many not being able to interpret the IR data.
- 4.3 Students were required to draw the repeating unit of an addition polymer from its monomer. Good students could do this but many could not.

Q5 Determination of relative molecular mass

- 5.1 Students were unsure about the use of high-resolution mass spectrometry to distinguish some compounds. Few referred to whether the M_r was the same or not to several decimal places. Many confused the technique with IR spectroscopy.
- 5.2 This question contained an experimental method that was unfamiliar to students. However, many managed to work out the correct answer. Common errors stemmed from conversion of volume / pressure / temperature into SI units.

Q6 Preparation of cyclohexanol

- 6.1 Students were required to complete an equation to balance it. Good students found this straightforward but many struggled. Many included the catalyst on both sides of the equation which did not score the mark.
- 6.2 Students had to complete a partial mechanism by adding 3 arrows. It was answered quite well but the final arrow for breaking the O-H bond was often incorrect.
- 6.3 This was an unusual calculation to find the amount of phosphoric acid in a volume of 85% acid. Many students managed this well but a common error was to forget to take into account the fact it was 85% rather than 100% acid.
- 6.4 Students needed to explain why water should enter the bottom rather than the top of the condenser. Responses were mixed but better students could explain it was to ensure the whole condenser filled with water so making it colder to enable better condensing of the vapour.
- 6.5 Many students could explain why anti-bumping granules are used.

- 6.6 This distillation is heated with an electric heater rather than a Bunsen burner because the alcohol is flammable. However, many students thought that it was to control the temperature, but this can be done effectively with a Bunsen burner and the actual reason was due to the flammability of the alcohol.
- 6.7 The apparatus as shown was dangerous as the system was sealed. Some students thought the opposite and that the system needed sealing. Some appreciated there needed to be an opening but thought it should be before the condenser not appreciating that the product would escape before it condenses. The best students could explain about having the system open in some way near the end of the condenser when the distillate is collected.
- 6.8 Most students could name the elimination mechanism. Dehydration is the reaction type but not the name of the mechanism.
- 6.9 Many students could write an equation for the complete combustion of cyclohexanol.
- 6.10 Students appear to think that carbon-neutral refers to the release of carbon rather than carbon dioxide into the atmosphere. The specific description of no net emissions of carbon dioxide to the atmosphere was not well known. In terms of explaining why the fuel was not carbon-neutral, many stated that it was because it releases carbon dioxide when it burns, but carbon-neutral biofuels do release carbon dioxide (but no net increase to carbon dioxide levels from its use). Some students referred to use of transportation in its manufacture but did not specify the use of fossil fuels for that transport.

Q7 Enthalpy changes

- 7.1 Many students could define enthalpy change but a large number could not.
- 7.2 In this calculation, students were required to determine the mass of ethanol burned from the temperature change of water it heated on burning. Many students managed this successfully.
- 7.3 Students needed to show that the sum of the bond enthalpies for the products in a reaction equated to $2536n + 926$. The best students could do this, but too many used brackets incorrectly in expressions that were mathematically incorrect.
- 7.4 Students had to determine a value of n in an alkane and its formula using expressions for the sum of the bond enthalpies in both the reactants and products. A common error was to only use the sum for the products or the reactants and not both, or to have sum the wrong way round where it would equal +3302 not -3302.

Q8 Organic nomenclature

This was answered correctly by a majority of students but many thought it was a ketone rather than an aldehyde or did not appreciate that the aldehyde group was C-1 and so the methyl group was on C-3 not C-2.

Q9 Catalytic converters

This was answered correctly by a majority of students.

Q10 Catalytic cracking

This was answered correctly by a majority of students, but many did mix up aspects with thermal cracking.

Q11 Oxidation of alcohols

This was answered correctly by a majority of students.

Q12 Cahn-Ingold Prelog Priority rules

The correct answer was the most common answer, but many thought the compound was *E* not *Z* possibly as they looked at the relative mass of the whole group attached to the C of C=C rather than the relative mass of the first atom attached.

Q13 Oxidation of alcohols

The correct answer was the most common answer, but it appears that students found it hard to deal with the different oxidations of the three alcohol groups.

Q14 Sulfur dioxide

The most common answer was incorrect. SO_2 reacts with CaO to form CaSO_3 and not CaSO_4 as the main product. Fewer students appreciated that SO_2 contains polar bonds.

Q15 Ozone decomposition

This was answered correctly by a majority of students.

Q16 Fractional distillation of crude oil

This was answered correctly by a majority of students.

Q17 Greenhouse gases

This was answered correctly by a majority of students, but many thought that propane or water were not greenhouse gases.

Q18 Hess' cycle

Students struggled with this question. Common errors were thinking that the cycle involved 6 x the enthalpy of combustion of hydrogen rather than 3 x, and/or making an error with sign for the required reaction.

Q19 Maxwell-Boltzmann distribution curve

This was answered correctly by a majority of students.

Q20 Relative reaction rates

Students found this hard although the correct answer was the most common response. Students struggled to appreciate the impact of limiting reagents on the volume of gas formed.

Q21 Chlorination of alkanes

This was answered correctly by a majority of students.

Q22 Enthalpy of formation

Students found this hard although the correct answer was the most common. Students struggled to appreciate that iodine is a solid and/or that the equation for the enthalpy of formation must form one mole of the compound.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the [Results Statistics](#) page of the AQA Website.