

Examiners' Report

June 2019

IAL Chemistry WCH12 01

Introduction

This is the first opportunity for candidates to sit the Pearson Edexcel International Advanced Subsidiary Level in Chemistry Paper WCH12_01. The style of the paper is similar to that for the legacy paper WCH01_01 with Section A containing 20 multiple-choice questions and Section B containing 60 marks of structured questions.

There are some minor changes to the content assessed on this paper compared to the legacy specification. The energetics topic has been split up and moved from Unit 1 to Units 2 and 4 and shapes of molecules and ions has been moved from Unit 2 into Unit 1.

Core practicals have been highlighted in the specification and there is a requirement to ensure 20% of the marks available assess mathematical skills at Level 2 (GCSE equivalent). For the first time on the IAL specification, paper 2 contains a 6 mark extended writing question.

Some candidates were very well-prepared for this examination and scored high marks. The excellent mathematical skills of the cohort were evident, especially when questions were set in a familiar context, e.g. determining the number of moles of water in a hydrated salt. However, the first opportunity to demonstrate the ability to structure an extended response proved challenging for many, as did the application of key ideas to a practical context. In a similar vein, answers explaining solubility, both in a molecular and ionic context, lacked clarity and depth and tended to be generic in nature. Candidates would benefit from attempting to express their ideas in terms of the strength of specific solvent-solvent/solute-solute interactions compared with solvent-solute interactions.

Question 19 (a)

Compiling an ionic equation from redox half-equations proved to be challenging. The oxidation of iodide ions to molecular iodine was the most commonly seen mark, but only the most able candidates seemed able to work out what happened to the hydrogen peroxide in the process.

Examiners commonly saw the inclusion of oxide ions, as well as hydroxide ions, however the guidance in the question stated that the hydrogen peroxide was acidified.

Despite this, a significant minority managed to construct the overall equation in Q19(a)(ii), regardless of their response in Q19(a)(i).

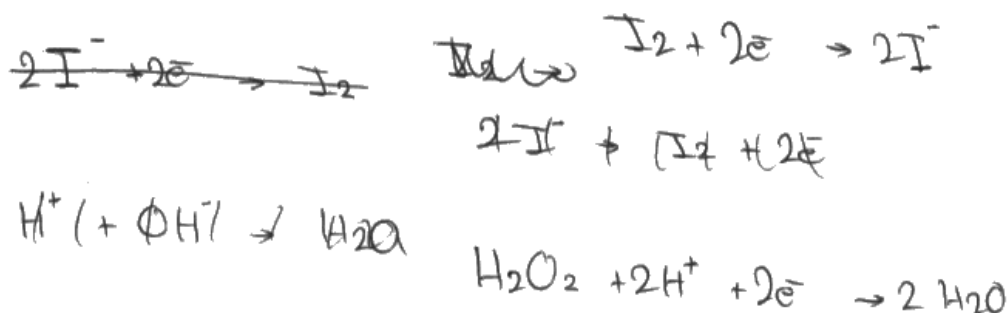
19 Iodine can be extracted from seaweed. The seaweed is heated strongly to burn off the organic matter. The resultant ash is boiled in water to dissolve the iodide ions, and the mixture is filtered.

(a) Acidified hydrogen peroxide (H_2O_2) is added to the filtrate.

A redox reaction takes place with iodine and water as the only products.

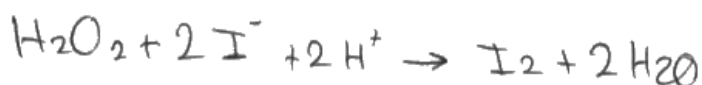
(i) Write half-equations for the oxidation and reduction reactions that take place. State symbols are not required.

(2)



(ii) Use your answers to (a)(i) to write the overall equation for this redox reaction. State symbols are not required.

(1)



In Q19(a)(i), this candidate has produced a correct equation for the reduction of hydrogen peroxide, but the iodine is also being reduced, so only scores 1 mark. However in Q19(a)(ii), they have correctly written the overall equation.



When writing two half-equations, check that the electrons do not appear on the same side in both cases. If they do, double check your answer as you cannot have both half-equations showing reduction (or oxidation).

Question 19 (b) (i)

There was evidence that candidates had seen, or carried out, this experiment as most answers contained at least one correct colour, normally the purple of the iodine in cyclohexane.

The appreciation that some iodine would remain in the aqueous layer was not always evident though, with many stating the aqueous layer would be colourless. Conversely, a smaller number thought a significant amount of iodine would remain in the water, so suggested brown or dark-brown.

- (b) The iodine is separated from the aqueous solution using solvent extraction. The aqueous solution is mixed with cyclohexane in a separating funnel, forming two layers.

The mixture is then shaken gently and left until the layers separate.

Most of the iodine dissolves in the cyclohexane layer.

- (i) State the colour of each layer **after** separation.

(2)

Aqueous layer colourless

Cyclohexane layer purple



This example illustrates the common misconception that no iodine would be found in the aqueous layer, hence the suggestion that it would be colourless.



Read the stem of each question with great care. Here the question refers to the idea that **most** (but not all) of the iodine dissolves in the cyclohexane layer. Hence some must remain in the aqueous layer, resulting in a yellow solution.

Question 19 (b) (ii)

Lots of candidates found it difficult to justify why iodine is more soluble in cyclohexane than water and many answers did not evolve far beyond the idea of 'like dissolves like'. Common misconceptions seen by examiners included:

- The formation of hydrogen bonds between iodine and cyclohexane.
- Discussions in terms of the iodine 'reacting' with water or cyclohexane.
- Answers framed solely in terms of differences of electronegativity.

The most common way to gain credit was for a rescue mark that allowed a simple comparison of the polar or non-polar nature of the three substances.

The best answers made it clear that they recognised the type of intermolecular forces present in each solute and solvent before dissolving, and its relative strength compared to the resultant intermolecular force between the solute and solvent.

(ii) Explain why iodine is very soluble in cyclohexane but only slightly soluble in water. (2)

Iodine is non-polar so it only has London forces. Cyclohexane also only has London forces. The ^{London} forces formed between iodine and cyclohexane can overcome bonds between iodine molecules and between cyclohexane molecules. Water forms hydrogen bonds. The bonds formed between water and iodine can't overcome the hydrogen bonding between water molecules. Hydrogen bonds are stronger.



This candidate has recognised the type of intermolecular force formed between iodine and cyclohexane and has made a comparative statement about the strength of the hydrogen bonds in water, so scored both marks.



Make sure you compare the type and strength of solute-solute, solvent-solvent and solute-solvent intermolecular forces in specific terms in this type of question.

Question 19 (c)

Most candidates could recall a suitable drying agent and so scored the mark here.

Some candidates, however, persist with the idea that any anhydrous salt is suitable.

Another common response saw candidates proposing more than one answer. In a question such as this, an incorrect answer contradicting a correct one will result in a mark of zero.

(c) The cyclohexane layer is then removed from the separating funnel and dried.

Identify, by name or formula, a suitable drying agent.

(1)

~~Calcium sulfate~~

Copper sulfate



A minority of candidates suggested copper sulfate as a drying agent which was not an acceptable answer. Whilst the anhydrous salt would absorb some water, its capacity for absorption is low and it is primarily used to simply indicate the presence of water rather than absorb large amounts of it.



Learn one of the common drying agents used in the core practicals, e.g. such as anhydrous sodium sulfate used to dry the halogenoalkane formed in core practical six (the chlorination of 2-methylpropan-2-ol with concentrated hydrochloric acid). This will be suitable for drying a huge range of organic liquids.

Question 20 (a) (i)

This question illustrates the difference between learning an answer and repeating it and understanding a concept and applying it.

Here, candidates had to apply their knowledge of Group 2 chemistry in an unfamiliar context and they often found this challenging. A number thought the use of the Bunsen would lead to the nitrate burning, whilst others thought the nitrate may 'spit' and lead to a variety of hazards or inaccuracies. A large number were concerned that removing the water too quickly would be problematic.

The best answers realised that the decomposition of the nitrate would lead to a lower mass remaining after heating.

20 This question is about compounds containing Group 2 elements.

(a) Hydrated magnesium nitrate has the formula $\text{Mg}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$.

A student devised an experiment to determine the value of x by leaving 5.12 g of hydrated magnesium nitrate for several hours in a warm oven. After this time, the solid remaining had a mass of 2.97 g.

(i) State why the student used a warm oven to remove the water from the hydrated salt, rather than direct heating with a Bunsen burner.

(1)

z> Using a bunsen burner will cause some hydrated salt to evaporate with water. Then mass of hydrated salt ~~would~~ would be less.



This example shows a common misconception that the ionic salt would evaporate along with the water, so did not receive any credit.



Practise as many exam-style questions as possible to improve your ability to apply the ideas you know to a range of scenarios.

Question 20 (a) (ii)

This question showed the candidates at their best. The lack of scaffolding in the question did not hinder progress and many candidates were able to score four marks, primarily by determining the mass and moles of water removed and comparing it to the moles of anhydrous magnesium nitrate.

A small number lost a mark as they did not give an integer value for x, but it was rare to see less than 2 marks awarded for this question.

(ii) Use the data obtained by the student to calculate the value of x.

You **must** show your working.

(4)

$$m_{\text{H}_2\text{O}} = 5.12 - 2.97 = 2.15 \text{ g}$$

$$n = \frac{m}{M_r} = \frac{2.15}{18} = 0.1194 \text{ mol}$$

$$M_r \text{Mg(NO}_3)_2 = 148.3$$

~~$$n = \frac{5.12}{148.3} = 0.03453$$~~

$$n_{\text{all}} = \frac{5.12}{166.3} = 0.03079$$

$$n = \frac{2.97}{148.3} = 0.02 \text{ mol}$$

$$0.0307 - 0.02$$

$$= 0.0107$$

$$0.1194 \div 0.0107$$

$$= 11.15$$

$$\approx 11$$

$$x = 11$$

~~$$\begin{aligned} 0.1194 &\div 0.02 \\ 0.02 & \\ \hline 5.97 &: 1 \\ 6 &: 1 \end{aligned}$$~~



This answer shows the value of perseverance in a chemical calculation. The first two marks are evident for the mass and moles of water removed. The candidate then finds it difficult to deduce the moles of the anhydrous salt, eventually arriving at the incorrect value of 0.0107 mol, so does not score the third mark. However, they then correctly compare this to the moles of water to deduce a value for x of 11, which, though incorrect, is a consistent transferred error so scored the fourth mark. This gives a total of 3 marks.



Even if you think you might have made a mistake in an unstructured calculation, keep going. There is always the chance you may score marks for transferred errors if your working is clear, or an odd final answer may help you realise you've made an error and you can then check your answer.

Question 20 (b) (i)

Many candidates tried to frame their response in terms of intermolecular forces, so did not consider the formation of ions and their subsequent hydration. Of those who did realise magnesium carbonate was ionic, a large number believed the ions would form hydrogen bonds to the water, so struggled to access the second mark. The best answers simply thought about what happens when ionic compounds **do** dissolve and reversed this argument to explain why some ionic compounds **don't** dissolve.

(b) Magnesium carbonate, MgCO_3 , is a white solid used as an additive in foods.

(i) Explain, in terms of energy changes, why magnesium carbonate is insoluble in water. (2)

The It is because large energy is required to break the forces of attraction between Mg^{2+} and CO_3^{2-} . It is not possible from the water to provide that energy by hydration of ions. Thus MgCO_3 is insoluble.



In this example, this candidate has realised what needs to happen for the carbonate to dissolve and used this to explain the lack of solubility. They have scored both marks as they have realised that a large amount of energy is needed to break the forces of attraction between the ions (ionic bonds) and this is not compensated for by the magnitude of the energy that would be realised if the ions were hydrated.



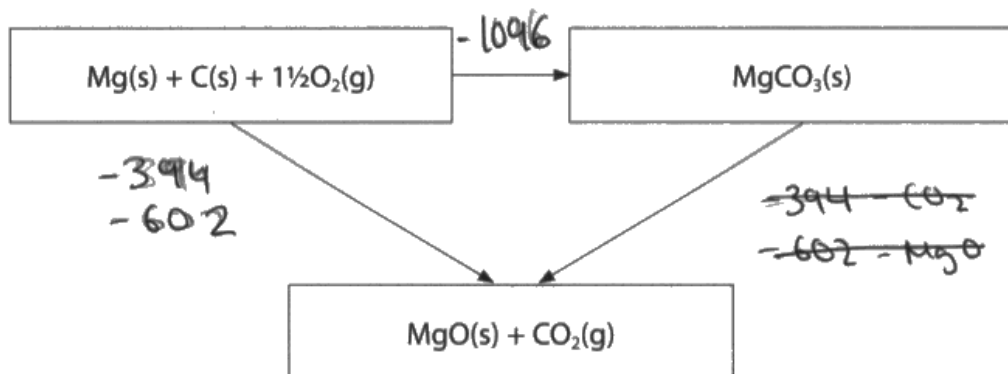
Practise using an idea or argument in reverse. For example, make sure you can explain what happens when ionic compounds dissolve in water, but then reverse the argument to justify why others don't.

Question 20 (b) (ii)

This calculation was a straightforward application of a Hess Cycle, and many candidates were able to score both marks. Common issues revolved around applying the cycle the wrong way around or confusion over the use of negative values in calculations.

Again, the need to take care was evident as examiners saw a number of values transposed incorrectly from the paper into the working of candidates.

(ii) The Hess cycle and data to calculate the enthalpy change for the thermal decomposition of MgCO_3 are shown.



Compound	$\Delta_f H^\ominus / \text{kJ mol}^{-1}$
$\text{CO}_2(\text{g})$	-394
$\text{MgO}(\text{s})$	-602
$\text{MgCO}_3(\text{s})$	-1096

Calculate the enthalpy change for the thermal decomposition of MgCO_3 .

(2)

$$= (-394 - 602) + (-1096) = -100 \text{ kJ mol}^{-1}$$



This example shows the most common error in this question leading to the negative rather than positive value. Such answers scored one mark, but this error could have been avoided if the context of the reaction was considered by the candidate. The reaction was a thermal decomposition, so must be endothermic and result in a positive enthalpy change.



When carrying out any chemical calculation, always check to see if the sign and magnitude of the numerical answer makes sense in the context of the question.

Question 20 (b) (iii)

Examiners were pleased with the quality of written explanations in this question, with a satisfying number of concise, yet accurate explanations.

The number of candidates confusing atoms, ions or molecules seemed fewer than in previous series and the vast majority of answers focused on the polarisation of the carbonate ion, without clouding the issue by discussing the level of covalent character, which is not relevant in this case. However, only the better candidates were able to link the polarisation of the anion to its effect on the carbon – oxygen bond.

(iii) Explain the trend in thermal stability of Group 2 carbonates.

(4)

Thermal stability of group-2 carbonates increases down the group because:-

(1) Size of cations increases down the group.

(2) Charge on the cations remain same.

(3) Charge density decreases.

(4) Polarising power of the group-2 cations decreases.

(5) Hence ~~group~~ down the group the ~~cations~~

← Positive ions cannot distort the

electron cloud of carbonate ion well enough.



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This succinct answer covers the first three marking points with clarity. To improve, it would need to discuss how the decreased polarising power of the cation impacts on the bond strength **within** the carbonate ion.



Practise explaining the opposite trend in similar contexts. For instance, make sure you can explain the trend in thermal stability of Group 2 nitrates as you go **up** the group.

Question 21 (a)

Whilst many candidates could name the reaction type in Q21(a)(ii), the correct use of water as the solvent in Q21(a)(ii) was less evident, with ethanol offered as an alternative. This probably arises from the use of a small amount of ethanol used to dissolve the halogenoalkane, but water must also be present to ensure the substitution reaction is favoured over elimination.

Candidates at the higher levels often produced excellent mechanisms, though weaker scripts revealed a number of common errors. These included:

- Arrows arising from incorrect positions e.g. from the carbon atom, rather than the C-Cl bond or from the negative charge on the hydroxide ion, rather than the lone pair.
- Absence of dipoles on polar bonds.
- Absence of lone pairs or a negative charge on the hydroxide ion.
- Use of K-OH in the mechanism, often with a curly arrow to denote the breaking of the K-O bond. This incorrectly implies the bond is covalent.

21 The halogenoalkane 1-chlorobutane reacts under suitable conditions with potassium hydroxide to form the alcohol butan-1-ol.

(a) (i) Name a suitable solvent for the potassium hydroxide in this reaction.

(1)

Water

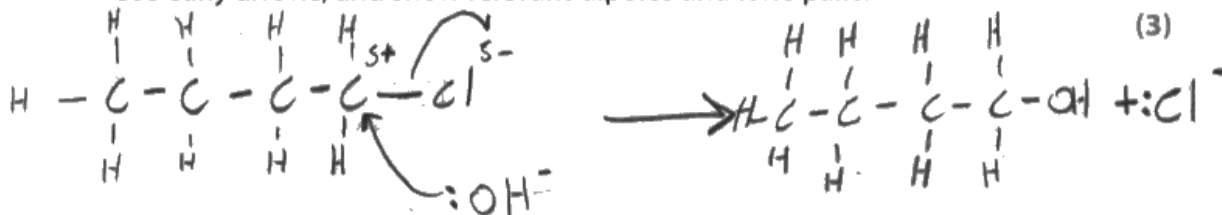
(ii) State the type and mechanism of this reaction.

(1)

nucleophilic substitution.

(iii) Draw the mechanism for this reaction.

Use curly arrows, and show relevant dipoles and lone pairs.





The solvent and reaction type in this example are correct and, at first glance, the mechanism looks fine as well. However, if you look closely at the arrow to the chlorine atom, it is clearly a half-arrow, used to denote the movement of a single electron. Hence the mechanism scores 2 marks, not 3. This occurred reasonably frequently, perhaps because candidates see the Cl atom and think of the homolytic fission of a chlorine molecule in free radical substitution reactions.



Remember the only time half-arrows are used at AS Level is in the halogenation of alkanes via a free radical substitution mechanism.

Question 21 (b)

This calculation discriminated effectively with the marks spread across the range. Those that scored 4 marks tended to follow the route shown in the mark scheme, though each of the steps could be done in any order.

The most common errors were the failure to take into account the 64% yield or to process the data simply in terms of masses and then volumes, rather than using amounts in moles.

(b) A student carried out the reaction.

After separation and purification, the mass of butan-1-ol formed was 12.1 g.

The yield of the reaction was 64.0%.

Calculate the volume of 1-chlorobutane used in the reaction.

Give your answer to an appropriate number of significant figures.

[Density of 1-chlorobutane = 0.886 g cm^{-3}]

$$\text{percentage yield} = \frac{\text{actual}}{\text{theoretical}} \times 100$$

$$64\% = \frac{\text{actual}}{\text{theoretical}} \times 100$$

$$64\% = \frac{12.1}{12.1} \times 100$$

$$0.08352 \times 92.5 = 7.744 \text{ g}$$

$$\text{actual} = 7.744 \text{ g}$$

$$\text{moles} = \frac{\text{mass}}{\text{Mr}} = \frac{7.744}{74} = 0.104648648$$

$$1 : 1$$

$$0.105 : 0.105$$

$$0.105 \times 92.5 = 9.68 \text{ g}$$

$$\text{volume} = \frac{\text{mass}}{\text{density}} = \frac{9.68}{0.886} = 10.9255079$$

$$= 10.9 \text{ cm}^3$$

$$\frac{7.744}{74} = 0.104648648$$

$$0.104648648 : 0.104648648$$

$$0.104648648 \times 92.5 = 9.68$$

$$\frac{9.68}{0.886} = 10.9255079$$

$$= 10.9 \text{ cm}^3$$



This answer shows another common mistake. The candidate has considered the yield but has scaled by $64/100$ instead of $100/64$. The rest of the steps are carried out correctly, so scored 3 marks.



Remember, when calculating the amounts needed for a reaction, a yield of less than 100% will always need you to use more reactant to compensate for the loss of product.

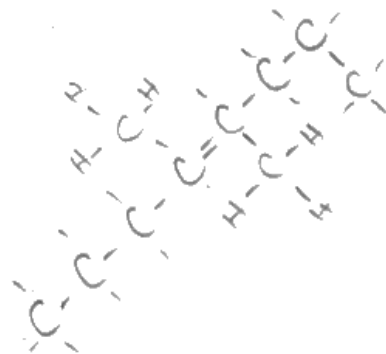
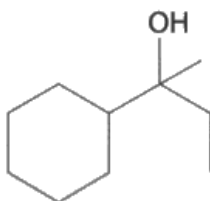
Question 22 (a)

Nearly all answers suggested PCl_5 or Na successfully as test reagents and it was extremely rare to see this accompanied by an incorrect test result.

A few students suggested acidified dichromate(VI) would give an orange to green colour change. This was not valid here though, as the alcohol was tertiary and aldehydes could also give a positive result.

A small number tried to hedge their bets, by giving two tests. Candidates should be aware that two answers, one correct and another that contradicts the first answer, will not receive full credit.

22 An alcohol Y has the structure shown.



- (a) Describe a **chemical** test and its positive result for the alcohol functional group in Y.

(2)

Add potassium dichromate along with ^{dilute} sulfuric acid.
The colour goes from orange to green.



This type of response was probably the most commonly seen incorrect answer. The use of acidified dichromate(VI) as a test reagent may be appropriate in the context to differentiating between two specific compounds, but as a generic test for the -OH functional group, it will not be valid.



Learn the tests for each organic functional group as described in the specification.

Question 22 (b)

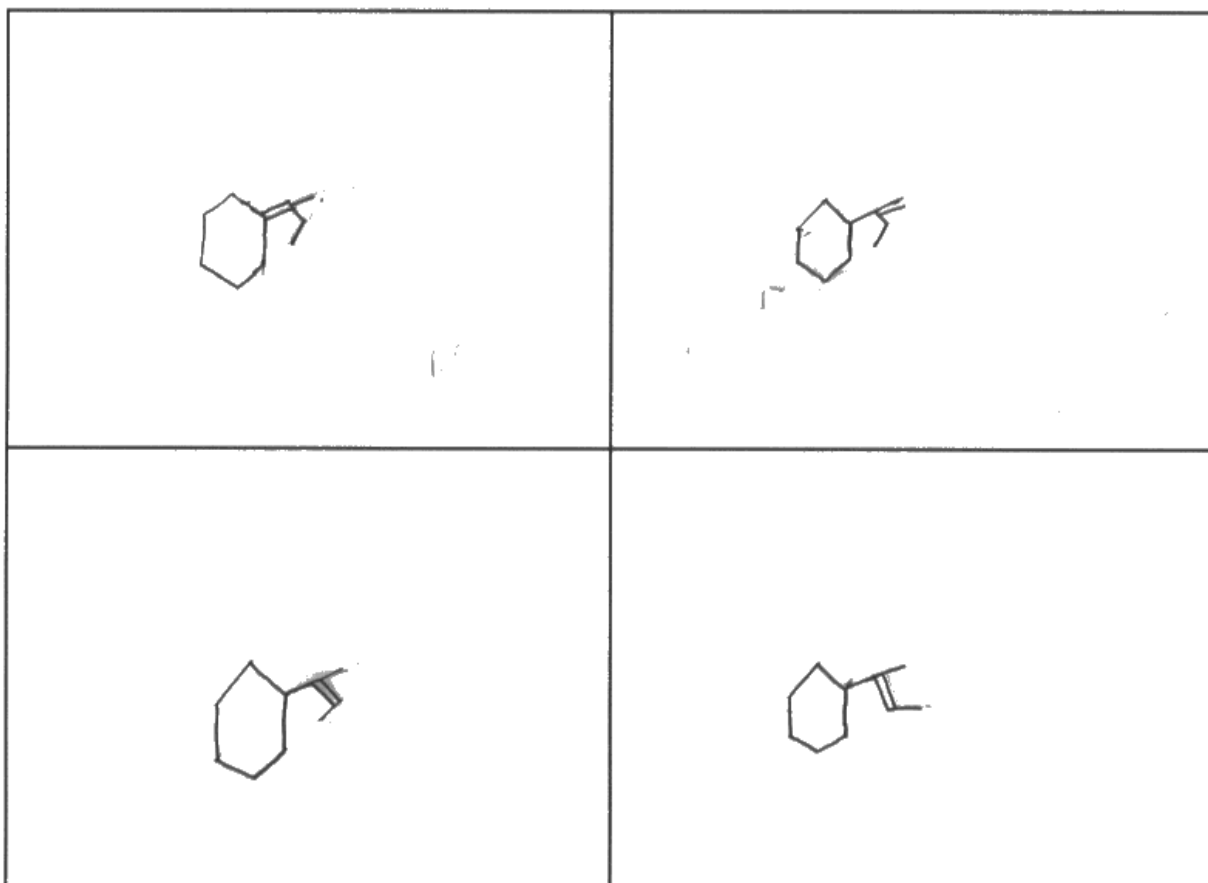
Q22(b)(i) tended to discriminate effectively in the A grade region. Below the higher grades, answers often show straight chain alkenes. Those who drew a cyclic structure often placed a double bond within the ring. Even better candidates sometimes missed one of the geometric isomers, drawing a fourth option that was the same as one of their other attempts.

In Q22(b)(i), many identified a peak due to the O-H bond in the original alcohol **Y**, linked to a correct wavenumber. In order to score full credit though, the answer needed to be specific about how the spectrum would differ and a significant minority simply stated the products would not have this peak. A few candidates tried to link a peak at 3095 cm^{-1} to the C=C bond, perhaps not reading the data booklet with enough care.

(b) **Y** reacts with concentrated phosphoric(V) acid, H_3PO_4 , to form four isomers with the molecular formula $\text{C}_{10}\text{H}_{18}$.

(i) Draw the skeletal formulae of the **four** isomers formed in this reaction.

(4)



(ii) Describe, by referring to wavenumbers and bonds, how the infrared spectra of the isomers differ from the infrared spectrum of alcohol **Y**.

(2)

Alcohol **Y** has a peak caused by O-H. The isomers doesn't have this peak, but they have a peak caused by C=C. They have different fingerprint regions.



In Q22(b)(i), this candidate has shown all four isomers correctly, scoring 4 marks.

In Q22(b)(ii), although they have recognised the key difference in terms of bonds that cause peaks in each spectra, they have not linked these peaks to a correct wavenumber, so only score 1 mark.



Read the stem carefully to check any specific information required in your answer.

Question 22 (c)

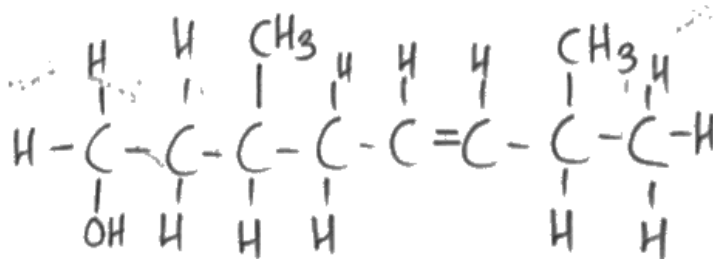
Whilst many fully correct answers were seen, the fine detail of the structure meant some candidates only scored 1 mark. The most frequent slips were:

- Positioning the double bond between carbon-5 and carbon-6.
- Omitting the double bond.
- Using skeletal structures with only 7 carbon atoms.

(c) An isomer of Y, citronellol, has the systematic name 3,7-dimethyloct-6-en-1-ol.

Draw the structure of citronellol.

(2)



The most common error on this example is shown here, with the double bond between the fifth and sixth carbon atom. It was awarded 1 mark.



Practise drawing and naming as wide a range of organic compounds as possible when revising.

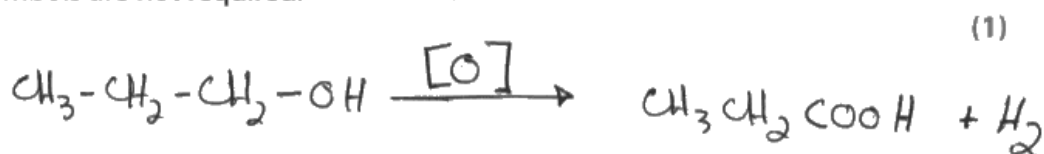
Question 23 (a)

Nearly all candidates could use the information in the question to show propan-1-ol and propanoic acid. However, the water also formed was often omitted or hydrogen shown as a product instead, so many did not score the mark.

It was reassuring, however, to see that candidates were familiar with the guidance from the specification about the use of [O] in such reactions and only a tiny minority tried to include an oxidising agent in their equation.

23 Propanoic acid, $\text{CH}_3\text{CH}_2\text{COOH}$, is a colourless liquid used as a preservative in animal feed. Propanoic acid can be formed by oxidising the alcohol propan-1-ol.

- (a) Write the balanced equation for the oxidation of propan-1-ol to form propanoic acid. Use [O] to represent the oxygen from the oxidising agent. State symbols are not required.



This answer illustrates the most common misconception seen by examiners. In an attempt to balance the equation, hydrogen is shown as a product, which is incorrect.



Remember that water is the second product formed in the oxidation of primary alcohols to carboxylic acids.

Question 23 (b)

The best answers focused with care on the specific requirements of the question and structured their response so each point was made independently and with clarity.

Other responses included a lot of correct content but adopted a scattergun approach and included extra detail not required by the question. Whilst correct, but not relevant information, can be ignored by examiners, additional incorrect chemistry can lead to less credit.

It was common to see candidates successfully link concentration and temperature to rate and the idea that more particles have energy greater than the activation energy. However, answers based on 'more collisions' as a justification for the effect of concentration still persist, when a sense of the rate is required. Statements such as 'more frequent collisions' or 'more collisions per second' make this mark secure.

The most common extraneous detail surrounded the use of the condenser. It was often linked correctly to the idea that it would ensure **all** the alcohol was oxidised. However, candidates often then spent time drawing condensers and describing how to use them, which was not required in the question.

The most frequent point absent from answers was the use of excess/concentrated oxidising agent to ensure all the alcohol was oxidised.

*(b) Propan-1-ol is heated with a concentrated solution of acidified potassium dichromate(VI).

Explain how the conditions used affect the rate of the reaction **and** ensure that propanoic acid is the only organic product.

(6)

- A concentrated solution means concentration of the reactants is high and when concentration increases in aqueous solutions; rate of reaction also increases because reacting solute particles come closer together in a given volume; resulting in a greater frequency of collisions between reacting solute particles. A main condition of this reaction is to heat under reflux to ensure the production of only propanoic acid and not propanal. If distillation with addition was used; propanal would also form, therefore not giving 100% yield of propanoic ~~the~~ acid.

Also, strong heat must be used when heating under reflux, so rate of reaction increases as ~~the~~ temperature is increasing due to the heat from the bunsen burner ~~&~~ flame. This is because a higher proportion of molecules gain energy to have energy of equal ~~&~~ or greater than activation energy (minimum energy needed for ~~a~~ colliding particles to react); this leads to a higher frequency of successful collisions.



This response shows a clear attempt to cover the points required by the question. Notice how, in the stem, the candidate has underlined what they intend to cover in the answer, and hence provide a structure to their work. The only indicative point absent from the answer is the link between excess/concentrated oxidising agent and complete oxidation, so 5 marks were awarded.



In a 6 mark extended writing question, go through the stem carefully and highlight or underline the key points. Use your underlining to try to split the stem into 2 or 3 smaller questions and frame your answer accordingly. A small amount of time planning your answer may save you time ultimately. This may prevent you from wasting time writing about ideas that are not relevant to the question.

Question 23 (c)

A large number of responses gave an answer based on recall rather than application in this question. As a result, many candidates discussed the facts that universal indicator gives a large range of colours or changes colour gradually, rather than giving a sharp end point. These may be acceptable ideas in the context of a titration, but not in this case as a test reagent.

The correct answers, in the main, spotted that the oxidising agent was acidified, so would also cause the indicator to change colour. A surprising number thought the indicator would not change colour as propanoic acid was weak.

- (c) A student suggested using universal indicator to check for the presence of propanoic acid formed in the reaction mixture.

Give a reason why the result of this test is **not** likely to be conclusive.

(1)

There is acidified potassium dichromate (VII) which can also make the solution acidic.



This candidate scores the mark, using the stem to consider what else is in the reaction mixture that may interfere with the test for propanoic acid.



Read the stem carefully to look for guidance to help you answer a question.

Question 23 (d) (i)

- (d) The permitted mass of propanoic acid used in animal feed is in the range $1000\text{--}3000\text{ mg kg}^{-1}$. A titration method may be used to check the concentration of propanoic acid in animal feed.

A 50.0 cm^3 sample of propanoic acid solution was extracted from 50 g of an animal feed.

The sample was added to a volumetric flask and the volume made up to 250.0 cm^3 and mixed thoroughly. A pipette was used to transfer 25.0 cm^3 of the diluted acid into a conical flask containing an indicator.

The contents of the conical flask were titrated with a solution of sodium hydroxide, NaOH(aq) , with concentration $0.00668\text{ mol dm}^{-3}$.

The procedure was repeated twice and the results obtained are shown.

	Run 1	Run 2	Run 3
Titre/ cm^3	23.20	22.10	22.20

- (i) Phenolphthalein is a suitable indicator for this titration.

State the colour **change** at the end-point.

(2)

Pink to colourless



Here, the candidate has the correct colours but the wrong way round, so scores only 1 mark.



Don't assume that titrations always add acid to alkali or vice versa. Read the question to check the detail of the experiment to help.

Question 23 (d) (ii)

(ii) Suggest two possible reasons why the titre for Run 1 is greater than the other two titres.

(2)

- ① The burette may ~~be~~ have distilled water and it ~~isn't~~ isn't rinsed before with NaOH before adding NaOH, so the concentration of NaOH in burette decreases
- ② the volumetric flask may contain more than ∇ 25 cm³ acid.



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Examiner Comments

This example shows the candidate had thought about the titre and the suggestion that only distilled water was used to rinse the burette was worth credit.



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Examiner Tip

When carrying out core practicals that involve titrations, go through all the common errors and think about their impact on the final outcome. These could include:

- Inappropriate substances used to rinse pipettes / burettes.
- Failure to remove air bubble in burette jet.
- Leaving a funnel in the top of the burette during the titration.
- Not swirling flask during titration.
- Not rinsing any splashes from sides of the conical flask during titration.

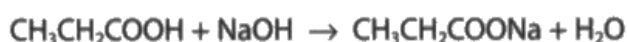
Question 23 (d) (iii)

The unstructured format of this calculation provided an increased level of demand from candidates, though many rose to the challenge.

The most common errors were the failure to scale by a factor of 10, to take into account the volume of the sample titrated compared to the volume of water used to dissolve all of the animal feed in the volumetric flask, and frustratingly, the number of significant figures in the final answer.

Sometimes working was hard to follow and time spent labelling steps may be beneficial when candidates practise similar examples.

(iii) The equation for the reaction of propanoic acid with sodium hydroxide is



Calculate the mass in grams of propanoic acid extracted from the animal feed.

Give your answer to an appropriate number of significant figures.

(5)

$$V = (22.10 + 22.20) \div 2 = 22.15 \text{ cm}^3$$

$$\therefore n(\text{NaOH}) = (22.15 \div 1000) \times 0.00668 = 1.47962 \times 10^{-4} \text{ mol}$$

$$\therefore n(\text{C}_3\text{H}_6\text{O}_2) = 1.47962 \times 10^{-4} \text{ mol}$$

$$\therefore M_r(\text{C}_3\text{H}_6\text{O}_2) = 74 \text{ g mol}^{-1}$$

$$\therefore m(\text{CH}_3\text{CH}_2\text{COOH}) = 74 \times 1.47962 \times 10^{-4} \times 10 = \overset{0.109}{\cancel{0.0109}} \text{ g (2 s.f.)}$$



This example illustrates many positive features. The working is easy to follow and clearly laid out. The candidate has stored intermediate values in their calculator, so no errors due to inappropriate early rounding are evident.

Unfortunately, the final answer is rounded incorrectly, as it should be 0.11g to 2 significant figures, so 4 marks were given.



Take care when rounding final answers to an appropriate number of significant figures.

Question 23 (d) (iv)

The final calculation proved difficult for many candidates, even some of those who had been successful in Q23(d)(iii). The ability to convert the mass into mg was the most commonly awarded mark, with fewer candidates able to scale to mg per kg.

Failing to score full credit in Q23(d)(iii) did not inhibit some though, who went on to score both marks as transferred errors. This was the only question on the paper where examiners commented on a higher than expected number of blank responses. This didn't appear to be a lack of time though, as virtually all candidates went on to attempt the final question.

(iv) Use your answer to (d)(iii) to determine whether the acid in this sample lies within the permitted range for use in animal feed.

(2)

$$50\text{ g} = 0.05\text{ kg}$$

$$0.1095\text{ g} = 109.5\text{ mg}$$

$$\frac{109.5\text{ mg}}{0.05\text{ kg}} = 2190\text{ mg kg}^{-1}$$

$$1000 \leq 2190 \leq 3000$$

So it ~~is~~ within the permitted range



Carrying through an answer of 0.1095g from Q23(d)(iii), this candidate correctly scales their answer to mg per kg of animal feed, and comments on the value compared to the permitted range, so scores both marks.



Practise converting to and from a range of units, as required by the mathematical skills outlined in the specification.

Question 23 (d) (v)

Most candidates were able to suggest an acceptable effect on the animal feed if the propanoic acid was outside the permitted range, nearly always based increased levels of acidity.

Some candidates wrote at length, perhaps hoping to hit on a creditworthy idea, but ended up contradicting themselves. For instance, suggesting that too much propanoic acid would increase the pH of the feed.

(v) Suggest how the animal feed would be affected if the amount of propanoic acid was outside the permitted range.

(1)

They It could cause harm to animals



The idea that the excess/too little propanoic acid may harm the animals was not enough on its own, so this example did not score. To improve, this answer would need to go on and give an example of how the propanoic acid being outside permitted range could harm the animals or affect the feed.



The term 'harmful' will rarely be worth credit on its own. Try to think about how or why a particular situation might be harmful.

Paper Summary

Based on their performance on this paper, candidates are offered the following advice:

- read the question carefully and make sure that you are answering the question that has been asked;
- plan your answer to extended writing questions by breaking the question down into 2 or 3 smaller questions;
- show all your working for calculations and make sure you round your final answer to an appropriate number of significant figures;
- think about your final value in chemical calculations to check it makes sense in the context of the question;
- learn about the factors that influence the solubility of simple molecules and ionic compounds;
- in organic chemistry practise applying your skills and recall of reactions to a range of different, more complex molecules;
- learn about equations for oxidation reactions of alcohols and aldehydes.