

A LEVEL

Examiners' report

CHEMISTRY B (SALTERS)

H433

For first teaching in 2015

H433/02 Summer 2023 series

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Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers is also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

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Paper 2 series overview

H433/02 is one of the three examination components for GCE A Level Chemistry B. This component, entitled 'Scientific literacy in chemistry', links together different areas of chemistry within different contexts, some practical, some familiar and some novel. The paper also includes questions based on a pre-released Advance Notice Article, included as an insert with the question paper. To do well on this paper, candidates need to have studied the pre-release material and to have researched some of the unfamiliar contexts included in this document. They also need to be comfortable applying their knowledge and understanding to unfamiliar contexts and be familiar with a range of practical techniques that they should recognise from completing the practical elements of the course.

This summer saw candidates sitting the exam who had been graded by Teacher Assessment in 2021 due to the ongoing problems caused by the Covid pandemic. These candidates will have probably been sitting public examinations for the first time, and, to their credit, they have done well on the whole on this paper. The most successful candidates demonstrated a knowledge and understanding of the subject material which clearly showed how much time and effort they had put into their studies and revision prior to sitting this examination.

In addition, candidates engaged well with both Level of Response (LOR) questions. Many candidates achieved at least a Level 2 on both questions, and the more successful candidates achieved a mark at Level 3 on Question 2 (e). There was also strong evidence that candidates had spent time with their teachers going through the Advance Notice Article "Calcium carbide" as the quality and depth of responses on Question 5 as a whole were particularly good.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
<ul style="list-style-type: none"> • performed standard calculations showing clear working and, where appropriate, conversion to the required number of significant figures in Questions 1 (d), 2 (b) (ii), 3 (a) (ii), 3 (a) (v) and 4 (b) • were able to discuss ideas about the Group VII elements and their compounds in Questions 1 (a) (i), 1 (a) (iii), 1 (c), and 4 (d) (ii) • showed a broad level of understanding of organic chemistry in Questions 2 (a) to 2 (d), Question 4 - all parts, and Questions 5 (e) and (f) • produced detailed responses on both level of response questions that accessed Level 2 as a minimum. 	<ul style="list-style-type: none"> • struggled to produce balanced chemical equations in Questions 1 (a) (i), 1 (c) (i), 3 (b) (i), 5 (d) (i) and 5 (d) (ii) • gave outlines to standard practical procedures but often did not include appropriate depth or detail in their answers/descriptions, e.g. Questions 1 (c) (ii), 2 (b) (iii), 4 (d) (ii) and 4 (f)

Questions 1 (a) (i), (ii) and (iii)

1 The element bromine is extracted from seawater.

Bromide ions are present in seawater in very low concentrations compared with chloride ions.

(a) (i) Excess chlorine is added to acidified seawater, forming aqueous bromine.

Write an **ionic** equation for the reaction of chlorine with bromide ions and explain how it shows that chlorine is more reactive than bromine.

Equation:

Explanation:

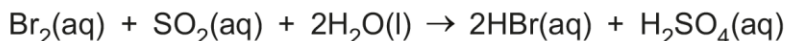
.....

[2]

(ii) Air is blown through the mixture to remove the bromine as a vapour.

Sulfur dioxide is then added, and the mixture is dissolved in water.

Bromine reacts to form concentrated HBr.



What is the oxidising agent in this reaction?

Explain your answer using oxidation states.

.....

.....

.....

..... [2]

(iii) Concentrated Br₂ is made from the concentrated HBr by displacement using chlorine.

Complete the table to give the properties of chlorine, bromine and iodine.

Halogen	Colour at room temperature	Physical state at room temperature
chlorine		
bromine		
iodine		

[2]

Question 1 (a) as a whole provided many candidates with an early opportunity to demonstrate their understanding of redox chemistry. In part (i) most candidates scored the mark for producing a balanced equation; those who did struggle here often omitted the '2' associated with the number of bromide or chloride ions in the equation. More successful candidates also identified that chlorine displaced bromine from the solution, or that chlorine oxidised bromide ions by removing electrons and that as a result of this chlorine atoms were reduced. This was then further assessed in part (a) (ii) where the oxidising agent, bromine, was usually correctly identified and an appropriate change in oxidation state, e.g. bromine going from 0 to -1, identified. Part (a) (iii) was often the trickiest part of this question. While candidates usually knew the physical state of the three elements there were a variety of incorrect colours given with yellow (gas) for chlorine and purple (solid) for iodine being the most common incorrect responses.

Question 1 (b)

(b) Some of the hazards of transporting bromine are similar to those of transporting chlorine.

Suggest **two** hazards of transporting bromine in a road tanker.

Hazard 1

.....

Hazard 2

.....

[2]

The majority of candidates scored at least 1 mark here, often identifying the toxic nature of bromine, with the most common incorrect responses stating that bromine was flammable, or that there was a danger of explosions due to the pressurised tankers being used to transport the liquid bromine.

Questions 1 (c) (i) and (ii)

(c) Some students add aqueous silver nitrate to a sample of seawater.

They expect to see a cream precipitate of silver bromide but the precipitate is pure white.

(i) Write an **ionic** equation for the reaction of silver ions with **bromide** ions.

Show state symbols.

[2]

(ii) Suggest why the students do **not** get the result they expect.

.....

.....

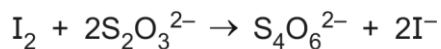
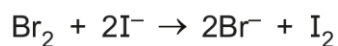
.....

..... [2]

The majority of candidates engaged fully with both parts of this question with very few candidates not attempting them. Across both parts of this question candidates often scored 2 marks; they often correctly gave the state symbols for the species involved in the ionic equation in part (c) (i) and then identified silver chloride as the precipitate in part (c) (ii). More successful candidates also gave a correctly balanced equation in part (c) (i). Where candidates of all abilities did struggle was in identifying that in seawater there is a higher concentration of chloride ions compared to bromide ions and so did not score full marks on part (c) (ii).

Question 1 (d)

- (d) The students titrate 25.0 cm³ of a solution of bromine with sodium thiosulfate in the presence of excess iodide ions.



They find that 24.65 cm³ of 0.380 mol dm⁻³ sodium thiosulfate is required to reach the end point.

Calculate the concentration of Br₂ in mol dm⁻³.

concentration = mol dm⁻³ [2]

This question links closely to one of the practical elements of the course. It was clear that candidates had carried out many titration calculations as there were very few candidates who did not score at least 1 mark here by calculating the amount of thiosulfate ions used in the titration. Many then progressed to attempt to calculate the concentration of bromine with most scoring the second mark. The most common error here saw candidates not dividing their number of moles of thiosulfate by 2 and consequently an answer of 0.375 (mol dm⁻³) was the most commonly seen incorrect response.

Question 1 (e)

(e) The students have another solution containing 20 g dm^{-3} bromine.

They find that 160 cm^3 of this solution reacts exactly with 0.80 g of a hydrocarbon with a molecular formula of C_6H_8 .

Suggest a structure for the hydrocarbon.

[4]

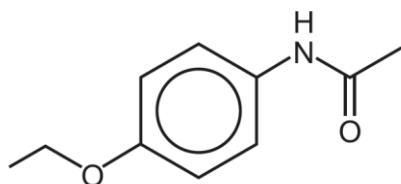
This question produced a wide range of responses from candidates. It was not unusual to see calculations of the numbers of moles of bromine and/or hydrocarbon with no attempt at a structure, or structures drawn without reference to any calculations – some with double bonds evident, some cyclic and some straight chained.

It was clear that the vast majority of candidates recognised that bromine is often used as a test for unsaturation in hydrocarbon molecules and that it was likely that the structure would include at least one double bond. Problems arose when candidates used a value of 79.9 (80) rather than 159.9 (160) in their calculations for the amount of bromine used as this gave rise to a value of 0.04 mole. Having correctly calculated the amount of the hydrocarbon as 0.01 mole this produced a ratio of $1:4$ which gave rise to structures containing too many double bonds.

There were some candidates who deduced that since bromine is used to test for unsaturation that the molecule had to contain at least one double bond, and then further deduced from the molecular formula that it was most likely to be a cyclic molecule containing two double bonds and therefore scored 2 marks.

Questions 2 (a) and (b) (i)

2 Phenacetin was used as a pain-relieving medicine until its harmful side-effects were discovered.

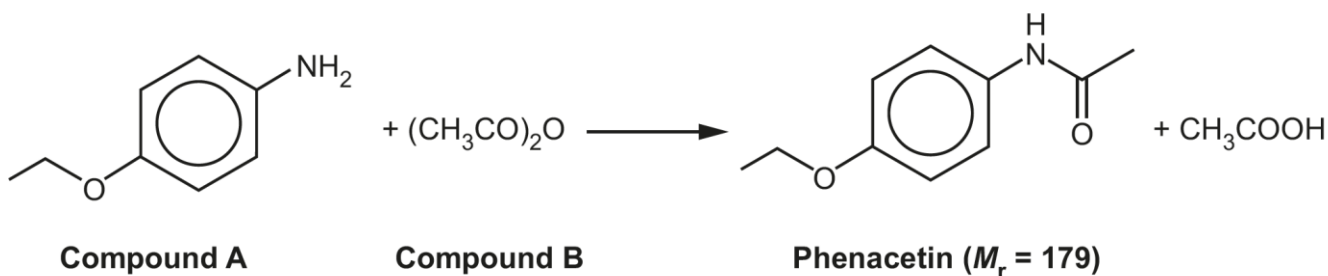


Phenacetin

(a) Phenacetin has a secondary amide group attached to a benzene ring. It also has one other functional group.

Name this functional group.

(b) Some students set out to make phenacetin from compound **A**, using the reaction shown. [1]



(i) Give the systematic name of compound **B**.

..... [1]

This pair of questions produced a mixed set of answers. In part (a) in addition to the correct response of ether, it was not unusual to see this group incorrectly identified as an ester or ketone. While in part (b) (i) the identity of compound B seemed to baffle many candidates. More successful candidates correctly identified the molecule but there were a variety of incorrect responses with ketones/esters being most common especially where the functional group in a) had been suggested as a ketone or ester.

Assessment for learning



When studying organic syntheses, e.g. the preparation of aspirin or other medicines, candidates should have the opportunity to interrogate complex molecules with a view to identifying the different functional groups present and to identify reagents used in their preparation.

Questions 2 (b) (ii) and (iii)

- (ii) The students use 14 g of both compound **A** and compound **B**.

Calculate the amounts of each (in mol) that show that compound **B** is in excess.

amount of compound **A** = mol

amount of compound **B** = mol
[2]

- (iii) The students recrystallise their crude phenacetin using water and obtain 20 g of solid product. They calculate their percentage yield.

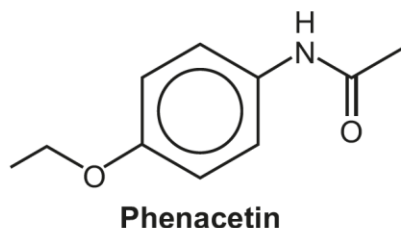
What advice would you give them?

.....
.....
..... [3]

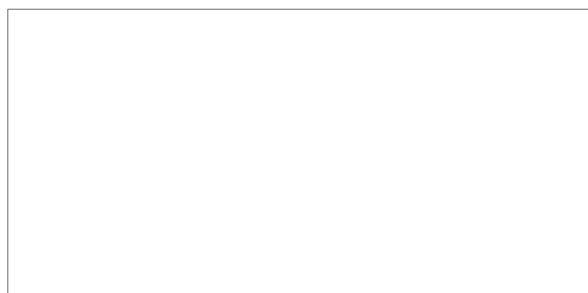
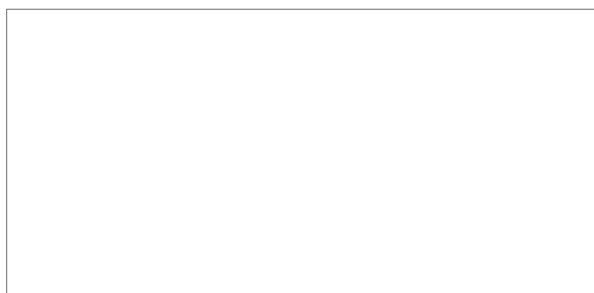
Both parts of this question were well answered by many candidates, with very few candidates not achieving at least 1 mark. Where a mark was not achieved in part (b) (ii) it was often a result of not calculating the formula mass of compound B correctly. In most cases this did not impact on part (b) (iii) as candidates recognised that compound A was the limiting reagent and so were able to calculate a value for the maximum yield of phenacetin. This was then used to state that the mass of product was impure or was used to show that the yield was greater than 100% allowing many candidates to score 2 marks on part (b) (iii). Where candidates did not score was in not identifying the need to re-crystallise the impure product again, or to dry it, as the original recrystallization had used water as the solvent and therefore it was likely that the impure compound was still wet and required drying before its mass/yield was determined.

Question 2 (c) and 2 (d)

(c) The students boil some phenacetin with aqueous acid.



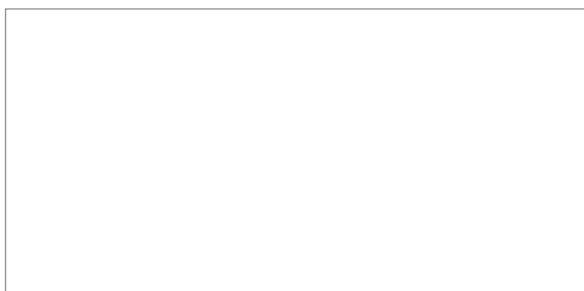
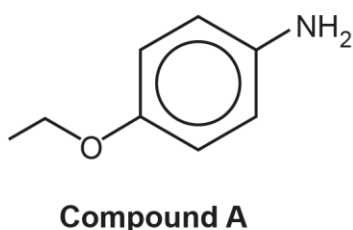
Draw the structures of the **two** products formed in the boxes below.



[2]

(d) Compound **A** reacts with propanoyl chloride.

Draw the **skeletal** formula of the organic compound formed in the box below.



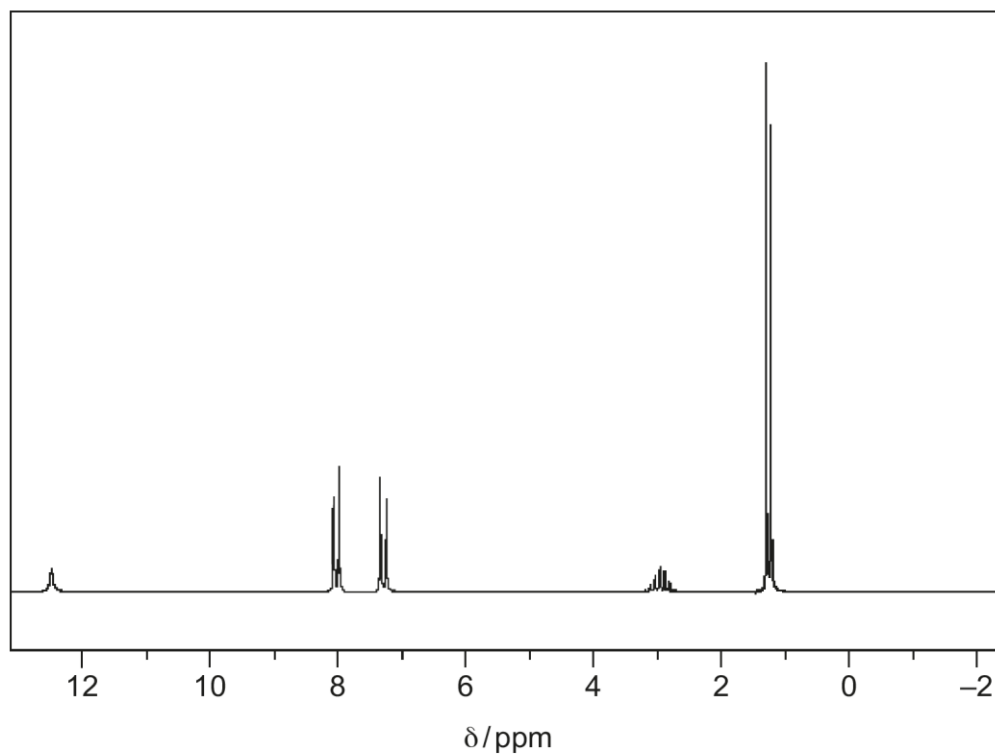
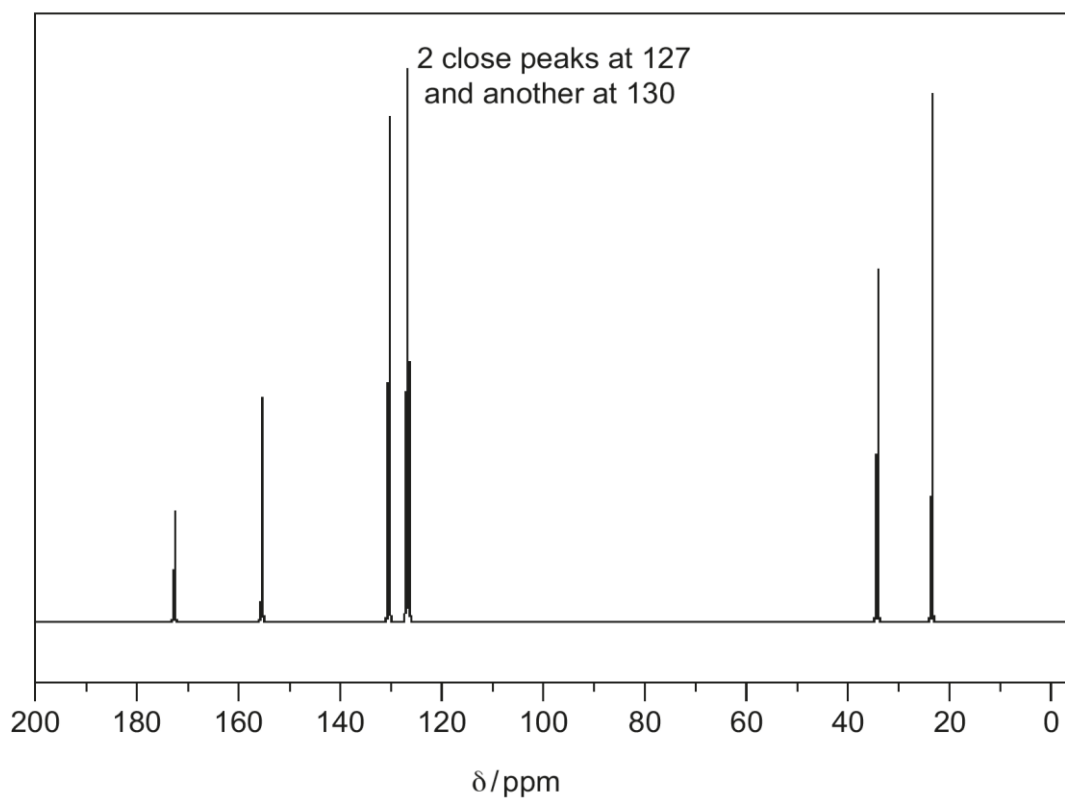
[2]

Many candidates struggled with this pair of questions and often lower attaining candidates left these questions blank. In part (c), candidates did recognise that the amide link would be broken to produce two molecules. Many candidates gave the ammonium fragment correctly but did not give a suitable structure for the ethanoic acid molecule and often simply produced the ethanoate ion as the second product of the reaction.

Part (d) should have seen the reconstruction of an amide link for 1 mark and recognition that the new amide was derived from the propanoyl group. Again, many candidates scored the first mark for identifying the amide link, but did not give the correct number of carbon atoms in the propanoyl fragment, or drew a full structural formula rather than the skeletal formula asked for in the stem of the question.

Question 2 (e)*

(e)* An aromatic acid has the formula $C_{10}H_{12}O_2$. Its NMR spectra are shown below.

 1H NMR ^{13}C NMR

Identify the aromatic acid.

Show how evidence from **both** spectra relates to the structure.

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[6]

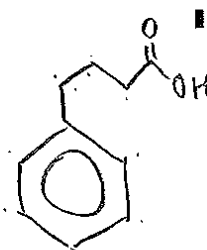
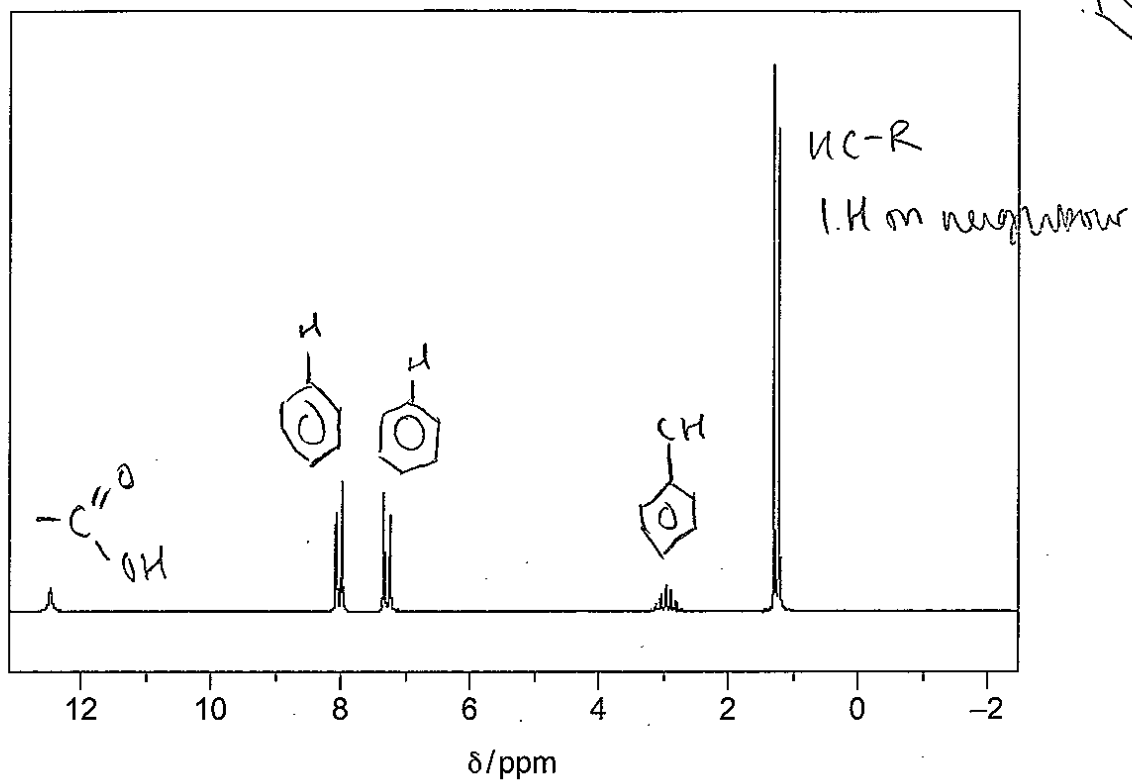
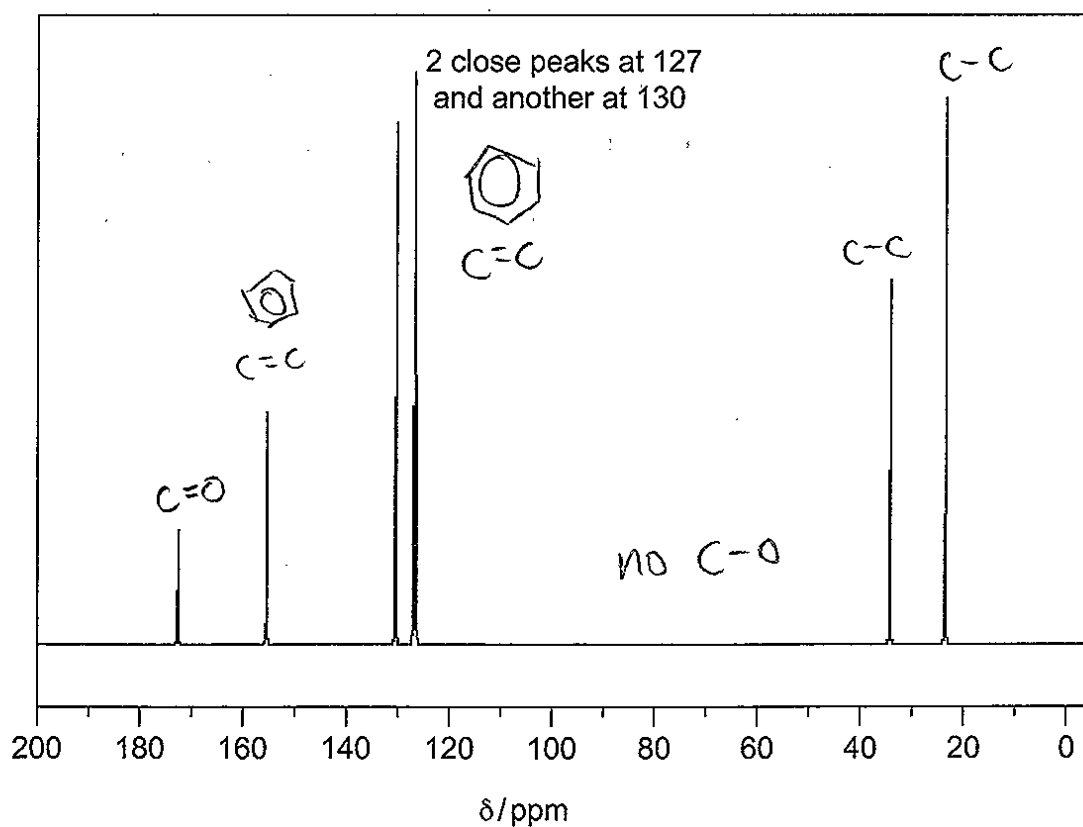
This was the first of the level of response questions on this paper and the vast majority of candidates made a good attempt to answer it.

Candidates often used their data sheets to identify the key peaks from both spectra. Some tried to interrogate the importance of the doublets and multiplets in both spectra in order to assist them in drawing the evidence together in order to try to construct an appropriate structure for the organic acid. This task was ultimately what prevented some candidates from accessing Level 3. However, if they approached the task by using the data in the two spectra, and attempted to produce a suitable aromatic acid structure then they could still score at Level 2.

Exemplar 1

8

(e)* An aromatic acid has the formula $C_{10}H_{12}O_2$. Its NMR spectra are shown below.

 1H NMR ^{13}C NMR

¹H NMR

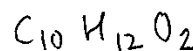
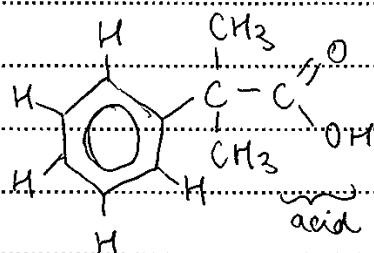
- doublet at 1.0 ppm indicates HC-R with 1 H on neighbor C
 - multiplet at 2.5 ppm indicates Cc1ccccc1 with many H on H on neighbor C
or HC-C(=O)
 - peaks at 7 & 8 ppm indicate c1ccccc1 with 1 H on neighbour C
 - peak after 12 ppm may indicate -C(=O)OH (carboxylic acid)
- 5 environments. (5 peaks)

¹³C NMR - 6 environments (6 peaks.)

- Peaks at ~25 & 35 ppm indicate C-C x2 environments
- No peak from 50-90 ppm indicates no C-O?
- Peaks at 127 & 130 indicate C=C and/or benzene
- Peak at 155 indicates C=C and/or benzene
- Peak at 170 indicates C=O. Both C=O must

Additional answer space if required:

therefore be in same environment as ~~20 ppm~~ 20 ppm present a carbonyl



- aromatic = benzene
- O₂ likely carboxylic acid

aromatic

In this response the candidate has approached the task in a logical manner and identified most of the relevant peaks in both spectra. They have then constructed their structure based on this and so score 4 marks at Level 2. This shows a reasoned structure containing an aromatic ring, a carboxylic acid group attached at the end of an aliphatic side chain, and the structure satisfies the molecular formula provided in the stem of the question. This 'partially correct structure' was often the most common interpretation of the data and allowed many candidates to score 4 marks.

Where candidates recognised the symmetry in the spectra with the data for the peaks at 120 – 140 ppm in the ¹³CNMR spectrum and δ7 – 8 ppm in the HNMR spectrum suggesting 4 aromatic Carbon atoms and 4 aromatic Hydrogen atoms which together produced two identical pairs this often allowed them to produce the fully correct structure and so they scored 6 marks.

Question 3 (a) (i)

- 3 There is concern about the amount of carbon dioxide produced when methane is burned in domestic gas boilers.

Hydrogen is being investigated as an alternative gas that could be delivered through adaptations of the present gas pipes to adapted boilers.

- (a) The traditional source of industrial hydrogen uses two processes that have the overall equation shown in **Equation 3.1**.



A high temperature is needed to obtain a reasonable yield of hydrogen in a reasonable time.

- (i) A student says that a **low pressure** is best for the industrial manufacture of hydrogen in **Equation 3.1**.

Discuss the student's statement.

Use relevant chemistry to support your answer.

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.....

..... [4]

Successful candidates correctly spotted that their response needed to focus on both the yield of hydrogen and the rate of production. Their answers were often characterised by identifying that the equilibrium would adjust in order to try to increase the pressure by moving to the right where there are the most molecules and so increases the yield of hydrogen. They also recognised that the reduced pressure meant that the reacting particles would have a lower collision frequency which would reduce the rate of production of the hydrogen.

Less successful candidates often addressed only one of these areas fully and did not address the other area.

Exemplar 2

There are 3 moles on the left hand side and 5 moles on the right hand side. Therefore increasing the temperature would favour the left hand side. So by having a low pressure you would be producing more H_2 therefore the student is correct.

In this response the candidate has correctly identified the effect of using a lower pressure on the equilibrium system and so they scored 2 marks. Had they gone onto include details on how a reduced pressure affects the rate of the reaction they could have scored full marks.

Many candidates produced responses that were very similar to this as they did not key into the part of the question which specifically stated that the conditions used produced a reasonable yield in a reasonable time, and so by changing the conditions this would change both the yield and the speed at which the hydrogen is produced.

Question 3 (a) (ii)

Equation 3.1 is repeated.



$$K_c = \frac{[\text{CO}_2] [\text{H}_2]^4}{[\text{CH}_4] [\text{H}_2\text{O}]^2}$$

- (ii) A mixture of 1.00 mol dm^{-3} $\text{CH}_4(\text{g})$ and 1.00 mol dm^{-3} $\text{H}_2\text{O}(\text{g})$ is allowed to reach equilibrium at 673 K in a container of volume 1.00 dm^3 .

The equilibrium concentration of H_2 is found to be $0.0705\text{ mol dm}^{-3}$.

Calculate a value for the equilibrium constant, K_c , for **Equation 3.1** at 673 K and give its units.

$K_c = \dots\dots\dots$ units $\dots\dots\dots$ [4]

This multi-step calculation produced a variety of responses from candidates.

Many identified the initial concentrations of the species in the equation, and then tried to determine the equilibrium concentrations of CO_2 , CH_4 and H_2O . More successful candidates achieved this and were then able to insert their values into the expression for K_c and often evaluated this successfully to score 3 marks. The fourth mark on this question was for the correct derivation of the units of K_c and again the most successful candidates did this. It was not unusual to see responses where the units were correct but the value of the equilibrium constant had been incorrectly evaluated even where the equilibrium concentrations had been correctly determined. Answers were also seen where the expression had been correctly evaluated but the units were incorrect.

The only common incorrect response saw candidates occasionally use the initial concentrations of CO_2 , CH_4 and H_2O as 1.0 mol dm^{-3} , and this gave rise to a value for K_c of $2.47 \times 10^{-5}\text{ mol}^2\text{ dm}^{-6}$ which scored 2 marks.

Question 3 (a) (iii)

(iii) K_c for the reaction is then measured again at an increased pressure.

Would the value of K_c be larger, smaller or the same?

Give a reason for your answer.

.....

..... [1]

This question produced a full set of possibilities both correct and incorrect. Where candidates indicated that K_c would change then irrespective of any reason produced, they scored 0 marks. The correct response here needed to first of all state that K_c would not change/stay the same, but then needed to explain why this was so in order to score the mark.

Many incorrect responses were in terms of how changing pressure would change the rate of the reaction, e.g. if the pressure was reduced the equilibrium would move to the right hand side as the rate of reaction would have increased. Alternatively, responses suggesting that K_c would decrease because the equilibrium had shifted to the left as there were fewer molecules on that side were also commonly seen.

Misconception



It is not unusual to see candidates misinterpreting questions regarding rate constants and equilibrium constants and how changing the reaction conditions influences these values. Therefore teachers should give some consideration of strategies they could employ to try to ensure that these ideas are embedded securely.

Questions 3 (a) (iv) and (v)

Equation 3.1 is repeated.



(iv) The table shows some entropy data.

Substance	$S^\circ / \text{J mol}^{-1} \text{K}^{-1}$
$\text{CH}_4(\text{g})$	186
$\text{CO}_2(\text{g})$	214
$\text{H}_2(\text{g})$	130
$\text{H}_2\text{O}(\text{g})$	189

Use the data to show that $\Delta S^\circ_{\text{sys}} = +170 \text{ J mol}^{-1} \text{K}^{-1}$ for the reaction in Equation 3.1.

[1]

(v) Use calculations to determine if the forward reaction in Equation 3.1 is feasible at 750°C .

Give a reason for your answer.

.....
 [3]

This pair of questions using ideas about entropy were very successfully answered by many candidates.

In part (a) (iv) they correctly illustrated how the value of ΔS_{sys} was arrived at using the data in the table provided to score 1 mark. In addition to this they then correctly stated the equation to use to calculate ΔS_{tot} for the system in part (a) (v) to score a second mark. Many then correctly made use of the additional data about ΔH and the temperature to attempt to calculate a value for ΔS_{tot} which would allow them to identify whether or not the reaction was feasible. The only common error seen in this question was not converting the temperature in $^\circ\text{C}$ into K, this resulted in candidates losing marking point 2 for part (a) (v) but they could still score marking point 3 from a correct deduction about the feasibility of the reaction dependent upon their calculated value for ΔS_{tot} .

Question 3 (a) (vi)

- (vi) The carbon dioxide produced by the process in **Equation 3.1** is a greenhouse gas.

Describe **two** ways in which greenhouse gases in the troposphere cause warming when they are irradiated by infrared radiation from the Earth.

1

.....

.....

2

.....

.....

[3]

Most candidates scored at least 1 mark for this question.

Most could identify that when the gas molecules absorbed infrared radiation this caused their kinetic energy to increase, or that the absorption of infrared radiation caused the bonds in the molecules to increase their vibrational energy. A significant proportion scored a second mark for linking these ideas together. Very few candidates recognised that once the infrared radiation had been absorbed that it required the excited molecules to re-emit it back towards the earth in order to cause warming of the Earth. The most commonly seen incorrect response was to state that the infrared radiation was reflected back towards the Earth.

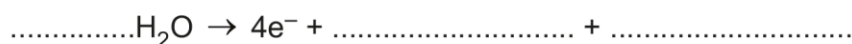
Question 3 (b) (i)

- (b) A potentially 'greener' method of making hydrogen is by electrolysis of acidified water.

- (i) The equation for the reaction at the cathode is shown.



Complete and balance the equation for the reaction at the anode:



[2]

Most candidates scored 1e mark for indicating that oxygen, O₂, was one of the products. The more successful candidates balanced the equation successfully by identifying the need for two molecules of water in the reactant and then including 4 H⁺ ions as the other product of the electrolysis.

Question 3 (b) (ii)

(ii) A mole of electrons is 96 500 coulombs. A coulomb is 1 amp flowing for 1 second.

How long (in hours) would it take for a current of 100.0 amps to produce 20.0g of hydrogen by electrolysis?

Assume 100% efficiency.

time = hours **[3]**

This calculation was attempted by the majority of candidates and many scored at least 2 marks.

Common errors that cost candidates a mark were either incorrectly calculating the number of moles of hydrogen molecules involved ($20/2=10\text{mol}$), or in recognising that 2 moles of electrons were required for each mole of hydrogen gas produced. These two errors often meant that candidates were a factor of 2 out in their calculation and as such the most commonly seen incorrect answer was 2.68 hours.

Where candidates only scored 1 mark this was usually for converting a time in seconds into a time in hours (marking point 3) by dividing their value for marking point 2 by 60 and then 60 again.

Question 3 (b) (iii)

- (iii) A student says that producing hydrogen by electrolysis is **not** 'green' because fossil fuels are used to make the electricity.

Discuss this statement.

.....

.....

.....

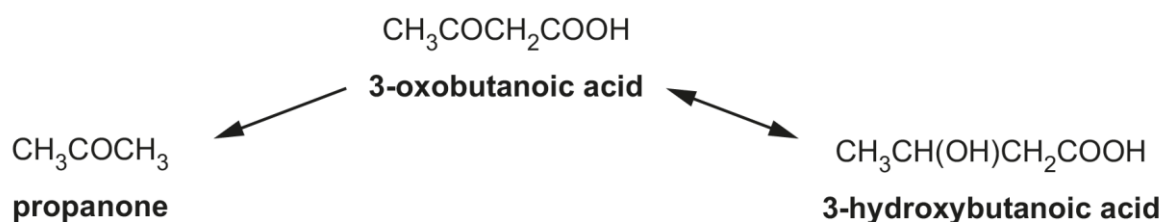
..... [2]

Candidates often struggled with this question. They often stated that using hydrogen to produce electricity was a green method, but unfortunately this does not answer the question and so did not score a mark.

Many candidates did however score at least 1 mark as they either identified that the use of fossil fuels was not green as they produced CO₂ or were not sustainable, or that there were other green methods of generating electricity such as solar or hydroelectric that could be used for the electrolysis process.

Question 4 (a)

- 4 3-oxobutanoic acid is formed from carboxylic acids in the liver in the human body. It is then broken down to produce propanone and 3-hydroxybutanoic acid.



These three compounds are known as 'ketone bodies' and are always present in human blood.

- (a) Name the **type** of reaction by which 3-oxobutanoic acid is converted to 3-hydroxybutanoic acid.

..... [1]

This question was poorly answered with few candidates identifying the type of reaction correctly. The most commonly seen incorrect responses were hydration or hydrolysis.

Question 4 (b)

- (b) A concentration of greater than $6 \times 10^{-4} \text{ mol dm}^{-3}$ of ketone bodies in the bloodstream is known as 'ketosis'.

Calculate the **mass** of propanone (M_r 58) (in grams) in 100 cm^3 of blood that contains $6 \times 10^{-4} \text{ mol dm}^{-3}$ of propanone.

Give your answer to an **appropriate** number of significant figures.

mass = g [2]

The majority of candidates scored 1 mark for correctly calculating the mass of propanone as $3.48 \times 10^{-3} \text{ g}$. Many did not score the second mark as they converted this to 2 significant figures rather than 1 significant figure, which was the appropriate number of significant figures consistent with the concentration given in the stem of the question.

Question 4 (c) (ii)

- (c) Ketosis can be detected by the presence of propanone in the breath.

Propanone can be recognised from its mass spectrum.

- (ii) Peaks are found at m/z values 15, 43 and 59 in the mass spectrum of propanone (M_r 58).

Give the origin of these peaks.

15

43

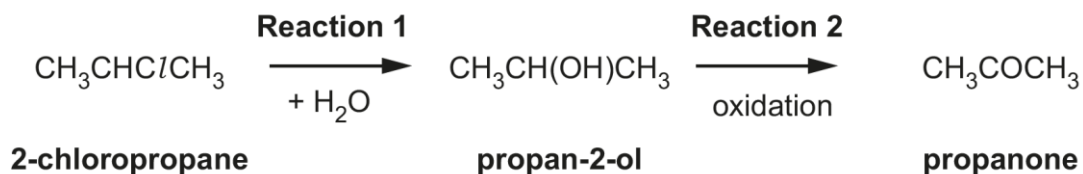
59

[3]

This question highlighted an area where candidates need to sharpen their responses. Most knew the identity of the fragments, but often did not include the charge on the ion. This was recognised within the mark scheme where examiners were instructed to penalise the omission of the + charge on the first occasion that it occurred and then to employ ECF (error carried forward) on subsequent occasions. This often resulted in candidates scoring 1 or 2 marks for the fragments at $m/z = 15, 43$ and 59 being identified but not possessing a + charge.

Question 4 (d) (i)

(d) A student proposes a reaction sequence for the formation of propanone.

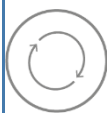


(i) Name the **mechanism** of Reaction 1.

..... [1]

As with Question 4 (a), the mechanism of this reaction was not well identified. The most common errors were to identify it as hydrolysis, which was ignored if the correct mechanism was subsequently stated, or simply to state substitution without reference to nucleophilic.

Assessment for learning



Design suitable revision resources for candidates that look at different organic reaction types and the mechanisms required associated with these reactions. These could be a self-assessed activity, a matching pairs activity or a set of multiple choice type questions to be used as a revision activity prior to the exam season beginning.

Exemplar 3

- Prepare 2-chloropropane, 2-bromopropane and 2-iodopropane by putting 0.1cm^3 of each solution in ~~one~~ 3 test tubes.
- Each test tube must have 1 haloalkane.
- Add 0.1cm^3 of ethanol and 0.1cm^3 of AgNO_3 .
- Observe the colour changes and how long it took for each solution to change colour.
 ~~$\text{Cl}_2 = \text{white precipitate}$~~ ,

[6]

In this response the candidate has discussed only a practical procedure. The method chosen uses a family of haloalkanes where the alkyl chain is kept constant and only the halogen atom is changed, they have then used equal volumes of each haloalkane and silver nitrate. They have added ethanol as a solvent to assist in allowing the haloalkane to react with an aqueous solution of silver nitrate. The response is not perfect, but the implication of timing is evident and the expected outcomes are stated. This response shows that option 3 at Level 2 from the mark scheme was applied, as, with no reference to the background theory the candidate had limited themselves to a maximum mark at Level 2, and a mark of 4 was given. Had they gone onto include details on how this procedure supported the relevant theory they would easily have accessed Level 3.

Question 4 (e)

- (e) Classify propan-2-ol, $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$, as primary, secondary or tertiary and give a reason for your answer.

Classification (primary, secondary or tertiary)

Reason:

.....

[2]

This question was very well answered by the majority of candidates and often full marks were given.

There were occasional responses from candidates where the classification was correctly stated but the reason given was missing or incomplete.

Question 4 (f)

- (f) Propan-1-ol is oxidised to an aldehyde rather than a ketone.

Describe a laboratory test, and its result, that would distinguish this aldehyde from propanone.

.....

.....

.....

..... [2]

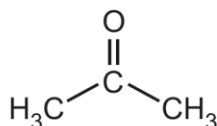
Most candidates could correctly identify a suitable reagent and observation to distinguish between the different carbonyl compounds. Where marks were lost in this question was in not stating the conditions required for the reaction to proceed. Responses omitted the need to heat/warm the reactants and so did not score marking point 1, but if the observation stated was consistent with the reagent used and the correct carbonyl compound then marking point 2 was given.

Questions 4 (g) (i) and (ii)

(g) Propanone reacts with CN^- ions in the presence of acid.

(i) Complete the mechanism for this reaction.

Show curly arrows, charges, lone pairs and the product.



[3]

(ii) Name the functional group formed in the product from (i).

..... [1]

This pair of questions were attempted by the majority of candidates with varying degrees of success.

In part (g) (i) many candidates showed the attacking species correctly. They drew a 'curly arrow' from a lone pair of electrons on the Carbon atom of the cyanide ion attacking the polarised carbon atom of the carbonyl group along with the simultaneous movement of a pair of electrons in the double bond towards the oxygen atom. This scored the first mark. However, marking point 2 was often not given as the intermediate structure drawn did not include either a lone pair or the negative charge on the oxide ion produced as a result of the initial attack by CN^- . However most candidates did then go onto score a second mark by correctly drawing the structure of the final product of the reaction.

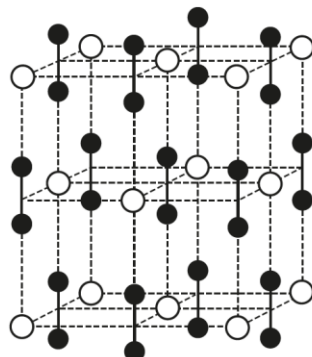
In part (g) (ii) most candidates who had completed the mechanism in part (g) (i) with the correct final structure identified this correctly as either a cyanohydrin, or as the alternative acceptable answer of hydroxynitrile. The more common incorrect responses saw the functional group named as an alcohol or as cyanamide which may have probably been chosen as a result of studying the advance notice article in preparation for Question 5.

Question 5 (a)

5 This question concerns the Advance Notice Article 'Calcium carbide' that is included as an insert with this paper.

(a) A diagram of the structure of calcium carbide is shown below.

Label a cation and an anion to show how the ions are arranged in the structure.



[2]

Many candidates scored 1 mark here by identifying the cation, Ca^{2+} , correctly and labelling it on the diagram. However, a significant number of candidates did not correctly identify the anion. They did not seem to appreciate that they needed to make clear that this ion contained 2 carbon atoms and so it was quite common to see a single black circle being labelled. To score the second mark a pair of black carbon atoms needed to be circled in the structure. An alternative to this was to allow a labelled arrow pointing to the bond between a pair of black circles

Question 5 (b)

- (b) The industrial manufacture of calcium carbide has benefits and disadvantages for modern society.

From the article, suggest **two** benefits and **two** disadvantages.

Benefit 1

.....

Benefit 2

.....

Disadvantage 1

.....

Disadvantage 2

.....

[4]

This question was very well answered by the majority of candidates, and it was not unusual for a mark of 3 or 4 to be awarded. It was clear that candidates had discussed this article with their teachers and that idea of benefits/advantages/disadvantages had been covered in the preparation of candidates for this paper. The only common errors seen involved discussions about carbide lamps, or the development of hydroelectric dams. Both of these are identified in the article but were not relevant to this question.

Question 5 (c)

- (c) 1.1 kg of a sample of impure calcium carbide produces 0.33 m^3 of acetylene (at RTP) when reacted with water.

Calculate the percentage purity of the sample.

percentage purity = % [3]

This calculation proved to be a very good discriminator as more successful candidates often scored full marks, whereas lower attaining candidates tended to score 0 or 1 mark for calculating the number of moles of acetylene correctly. Some candidates used the ideal gas equation to calculate the number of moles of ethyne produced as an alternative to the expected route and this was allowed as an alternative for marking point 1. A common error made having calculated the number of moles of ethyne was to then use the formula mass of ethyne in step 2 rather than the formula mass of calcium carbide that was required in order to assess the purity of the sample.

Question 5 (d) (i)

- (d) (i) Acetylene (ethyne) burns in a carbide lamp to form carbon dioxide and water. Some unreacted carbon is also formed that glows and gives light.

Write a possible chemical equation for the combustion of acetylene to give carbon dioxide and carbon.

[1]

This equation seemed to confuse some candidates. It was quite common to see equations that included only carbon dioxide and water as the products even though candidates were told that carbon was also produced in the reaction. Other incorrect equations included hydrogen as a product rather than water.

Question 5 (d) (ii)

(ii) Impure calcium carbide contains calcium phosphide.

The phosphide ion is P^{3-} .

Calcium phosphide reacts with water to form PH_3 .

Suggest a chemical equation for this reaction.

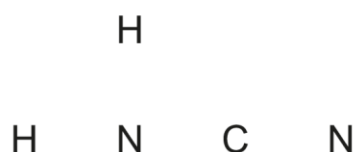
[2]

Most candidates scored 1 mark here for correctly determining the formula of calcium phosphide using the formula of the phosphide ion given in the stem of the question. Where candidates correctly identified that calcium hydroxide would be a co-product of the reaction, they often scored a second mark by writing a fully balanced equation. A common incorrect response saw calcium oxide given as the co-product.

Candidates who attempted to produce an ionic equation often struggled as they needed to identify that OH^- ions were produced in order to score marking point 1, and then needed to balance their equation in order to score marking point 2. If they did not identify the hydroxide ion as a product, they consequently scored 0 marks for this question.

Questions 5 (e) (i) and (ii)

(e) (i) Complete a 'dot-and-cross' diagram for cyanamide.



(ii) Suggest, with reasons, the bond angle for N–C–N in cyanamide.

.....

.....

.....

.....

..... [3]

This final pair of linked questions were often well answered. Candidates recognised the need to apply the octet rule in their 'dot-and-cross' diagrams and there were very few diagrams produced with incorrect numbers of electrons surrounding each atom. Consequently, if candidates recognised that there was a triple bond containing 6 electrons between the central carbon atom and the nitrogen atom on the right hand side of the diagram, they scored marking point 1. If they then applied the octet rule correctly for the species as a whole then they usually scored marking point 2 also. The only common error seen with these diagrams was the omission of a lone pair of electrons on one or both of the nitrogen atoms. Other incorrect diagrams included double bonds on either side of the central carbon atom, and occasionally diagrams where the octet rule had not been applied and one or more atom contained insufficient electrons.

Having drawn their diagrams candidates were then asked to identify and explain the bond angle for the N–C–N in cyanamide. If the diagram was drawn correctly the candidate usually scored at least 2 marks here by giving a value of 180° with the idea that the electrons surrounding the central carbon atom arranged themselves to minimise the repulsion between them. In order to score the third mark they needed to state clearly that there were two areas of electron density around the carbon atom; this point was occasionally not scored as an incorrect or vague description was given, e.g. the carbon atom is surrounded by two bonding pairs of electrons. This is almost correct but using the term bonding pairs implies that there were two single bonds rather than the correct single and triple bond combination.

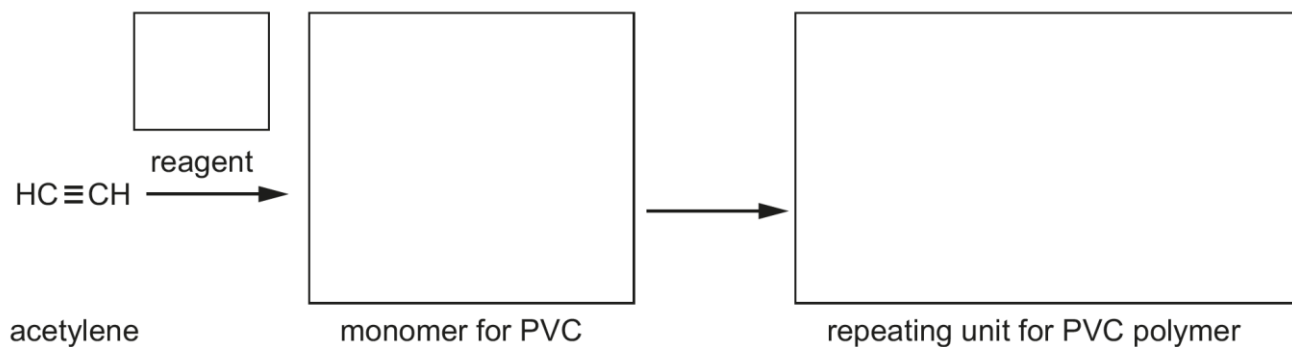
If the candidate drew an incorrect dot-and-cross diagram but then used it to determine an appropriate bond angle with a related description then by making use of ECF (error carried forward) between parts (e) (i) and (e) (ii) a mark of 3 could still be awarded for part (e) (ii). For example if they drew a diagram showing a triple bond to the right of the carbon atom, a single bond to the left of the carbon but had added a lone pair on the central carbon atom then they scored 1 mark for the triple bond in part (e) (i), but not marking point 2. Then by applying ECF if they gave a bond angle of 120° and explained it was produced as a result of there being three areas of electron density surrounding the central carbon atom, with the need to minimise repulsion between the 3 areas then they could score all 3 marks for part (e) (ii). This application of the ECF rule benefited a significant number of candidates.

Question 5 (f)

(f) PVC has the systematic name poly(chloroethene).

Complete the sequence below for the formation of PVC from acetylene.

Write a structural formula in each box.



[3]

The final question on the paper was attempted by the vast majority of candidates and provides clear evidence that candidates made good use of the time available for the paper as a whole.

Many candidates scored full marks on this question. Most incorrect responses either lost marking point 1 for the use of an incorrect reagent, or lost marking point 2 for drawing an incorrect structure, e.g. inclusion of a single bond rather than a double bond in the monomer. Where candidates lost marking point 2 for giving an incorrect formula of the monomer containing a double bond, e.g. $\text{CHCl}=\text{CHCl}$, but then used this to produce what they believed to be the correct repeating unit then ECF was applied and marking point 3 could be awarded. This allowed most candidates to score at least 1 mark on this final question as they had probably also lost marking point 1 for an incorrect reagent.

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