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Examiners' Report
June 2014

GCE Chemistry 6CH02 01

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Introduction

From the high marks and wide range of totals gained it is evident that this paper was accessible to the whole ability range and allowed all candidates to demonstrate what they had learned. There was no evidence that candidates had insufficient time to complete the paper. There remain the usual examination reminders which are highlighted in the summary.

The successful candidate was able to:

- apply their knowledge and understanding to new situations or substances, such as the reactions and properties of silane.
- write correct chemical equations, including those of a free radical substitution mechanism.
- complete a sequential series of calculations successfully and to appreciate the validity of the final answer.

The less successful candidate was unable to:

- use appropriate chemical terms and examples in their correct context and so frequently failed to gain credit as a result.
- explain clearly the reasons for outcomes such as bond lengths or why solutions should not be used.

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Question 20 (a) (i-vi)

This question proved to be a good discriminator, while enabling the whole ability range to gain some credit. Candidates still need reminding that if units are given, then they must be correct, for example at times mol dm^{-3} was incorrectly written. In addition rounding was at times done erroneously, for example 0.061375 was rounded to 0.0613 or 0.06137. Furthermore, the use of one significant figure of 0.06 in part iii) was penalised.

A sizeable minority incorrectly used the trial figure to calculate the mean of 24.7 but transferred error was applied so that the remaining marks could still be achieved.

The error most commonly seen in (a)(v) was the failure to multiply by 4 since the titration was only carried out on 25 cm^3. Another common error was the use of 35.5 as the Mr of HCl.

In (a)(vi) it was insufficient to simply affirm that the statement was or was not valid. The question asked for a justification. Hence some reference as to how close the value was to the manufacturer's statement or that if rounded to 1 significant figure that it was the same was required. There was some evidence of candidates not realising the reality of the situation by stating the difference of 0.04g made the statement invalid because it was too far away from the value given of 9g. Within the realms of the experiment and the use by the manufacturer of only 1 significant figure even a value of 0.50g away would have meant that the statement was valid.

Titration	Trial	1	2
Final Volume /cm^3	25.00	49.60	24.50
Initial Volume /cm^3	0.00	25.00	0.00
Volume Added /cm^3	25.00	24.60	24.50

(a) (i) Complete the table and calculate the mean titre by selecting the appropriate results.

(1)

mean = $\frac{24.60 + 24.50}{2} = 24.55$

mean titre = 24.55 cm^3

(ii) Write the equation for the titration reaction. State symbols are not required.

(1)

$HCl + NaOH \rightarrow NaCl + H_2O$

(iii) Calculate the number of moles of sodium hydroxide that reacted.

(1)

moles = vol × conc

$= \frac{24.55}{1000} \times 2.50$

$= 0.02455 \times 2.5 = 0.061375$

$= 0.0614$ moles (3 SF)

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(iv) Hence state the number of moles of hydrochloric acid that reacted with the sodium hydroxide.

(1)

1 : ratio

= 0.0614moles

(v) Calculate the mass of HCl present in 100 cm^3 of the toilet cleaner. Give your answer to 3 significant figures.

(2)

moles in $25cm^3$ = 0.061375

moles in $100 cm^3$ = 0.061375 × 4

= 0.2455

mass = Moles × Mr = 0.2455 × (1 + 35.5)

= 8.96075

= 8.96g (3 s.f.)

(vi) Using the technician's results, comment on the validity of the manufacturer's statement that the toilet cleaner contained 9 g of HCl per 100 cm^3. Justify your answer.

(1)

the manufacturer's statement is valid as 8.96g is extremely close to 9g. Therefore there is very little difference, and this difference could have been caused by error in the technician's experiment.

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Examiner Comments

This is an example of a completely correct answer. The rounding in (a)(iii) is correct and the conclusion in (a)(v) is acceptable. However it is unnecessarily long.

ResultsPlus

Examiner Tip

Keep your answer to the space provided. If you are writing beyond the space then it is likely that you are giving information that is not needed. In addition there is no need to re-write the question. In this example the candidate could have written *'It is valid because* ..' rather than *'The manufacturer's statement is valid because* ..'. and also omitted the reference to it having been *'caused by error in the technician's experiment.'*

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Question 20 (a) (vii)

This was generally a well-answered question, certainly by the middle and higher ability candidates. An answer referring to the corrosive or caustic nature of a sodium hydroxide solution of this concentration was required to score. Frequently references to the solution being harmful or hazardous or toxic or an irritant were seen but these were insufficient. Some even thought that the solution was explosive.

Occasionally answers were seen where the candidate referred to the solution as being too strong an 'acid' showing a complete misunderstanding which was disappointing.

(vii) Explain why titrations involving the use of a 2.50 mol dm^{-3} sodium hydroxide solution would **not** be advisable in a school or college laboratory.

(1)

High concentration of NaOH would be dangerous for students to use

ResultsPlus
Examiner Comments

This is an example of an answer which is too vague to be given credit. Yes the NaOH is of a high concentration and it could be said to be dangerous but in what way? A comment that it would damage the eyes or burn the skin is required.

(vii) Explain why titrations involving the use of a 2.50 mol dm^{-3} sodium hydroxide solution would **not** be advisable in a school or college laboratory.

(1)

This is a high concentration of a harmful substance meaning an accident could have serious consequences. Children cannot be trusted with it

ResultsPlus
Examiner Comments

This is another example of an answer which is not incorrect but insufficient. What are the serious consequences? What possible accident could occur? Harmful is never sufficient and is of no value here.

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Question 20 (b)

A straightforward dot and cross diagram that gave evidence of the grade E boundary as these candidates could be expected to get this question correct. Allowance was made for the variety of ways that the dot and cross diagrams can be drawn. The most common error was the omission of the lone pairs of electrons on the chlorine.

(b) Conventional toilet cleaners contain a bleaching agent. Chloric(I) acid, HOCl, is one such substance.

Draw the dot and cross diagram for chloric(I) acid. Show outer electrons only.

(1)

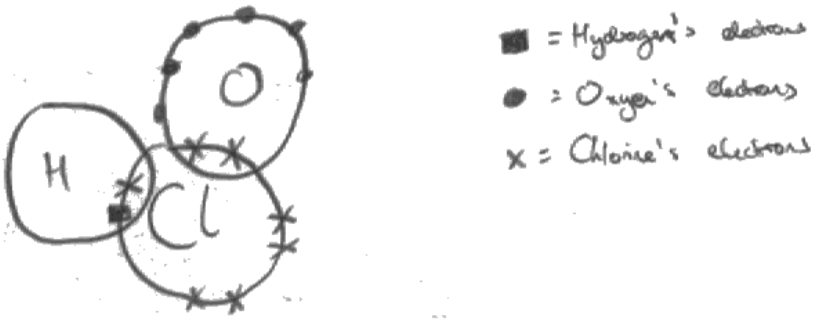
ResultsPlus
Examiner Comments

An example of a correct response, which is clearly drawn and awarded the mark.

(b) Conventional toilet cleaners contain a bleaching agent. Chloric(I) acid, HOCl, is one such substance.

Draw the dot and cross diagram for chloric(I) acid. Show outer electrons only.

(1)



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Examiner Comments

This is an example of an alternative answer that was given credit. The formula of the bleaching agent was purposely written as HOCl to give candidates guidance as to the arrangement of the atoms however this is ignored here. Nonetheless the dative covalent bond from the chlorine to the oxygen results in all of the atoms having a full outer shell and so this type of response was awarded the mark.

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Question 20 (c)

It was very common to see a correct equation. The second part of the question relating to why bleaching agents should not be mixed is a good example of How Science Works and an everyday application. It was answered well by many but as seen in (a)(vii) it was common to see vague answers such as chlorine is 'harmful/dangerous/hazardous'. Chlorine is a toxic, poisonous gas and either of these comments was required.

(c) The instructions for the use of Brand **X** state that the toilet cleaner should not be used with bleaching agents.

Complete the equation for the reaction between the hydrochloric acid in the toilet cleaner and the chloric(I) acid in the bleaching agent. Give a reason why this reaction is to be avoided in accordance with the instructions for the use of the toilet cleaner.

(2)

Equation $HCl + HOCl \rightarrow$ ~~H_2O~~ $H_2O + Cl_2$

Reason Cl_2 can ~~bleach~~ react with the bleaching agent.

ResultsPlus
Examiner Comments

This is an example where one mark can be awarded for a correct equation but the reason given is incorrect. It is the chlorine gas product which is toxic.

(c) The instructions for the use of Brand **X** state that the toilet cleaner should not be used with bleaching agents.

Complete the equation for the reaction between the hydrochloric acid in the toilet cleaner and the chloric(I) acid in the bleaching agent. Give a reason why this reaction is to be avoided in accordance with the instructions for the use of the toilet cleaner.

(2)

Equation $HCl + HOCl \rightarrow Cl_2 + H_2O$

Reason Cl_2 is toxic and so they should be mixed.

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Examiner Comments

An example of a response which scores both marks.

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Question 20 (d) (i)

A familiar example of disproportionation with oxidation numbers required, which candidates clearly had seen before and were confident in answering. It was good to see that the sign missing from the positive oxidation number of chlorine was rare. A reasonably generous view was taken of the spelling of disproportionation as long as the meaning was clear but candidates should be able to spell this specific word correctly.

(i) Give the oxidation numbers of the chlorine-containing species in the equation below and classify the reaction as a result of your answer.

$$2NaOH(aq) + Cl_2(g) \longrightarrow NaCl(aq) + NaClO(aq) + H_2O(l)$$

Oxidation Number: 0 ; −1 ; +1

(2)

Type of reaction: Redox

ResultsPlus
Examiner Comments

The oxidation numbers are clearly correct and gain the first marking point but redox is too vague as disproportionation is a specific type of redox.

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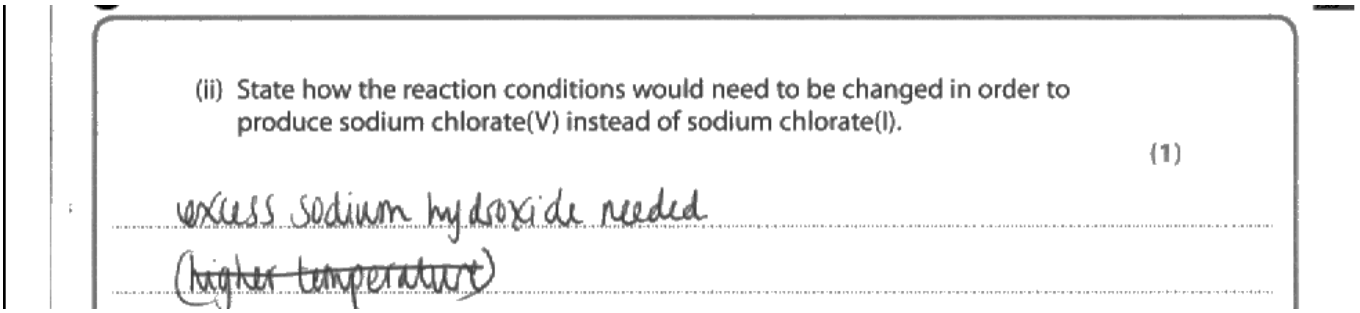
Question 20 (d) (ii)

The expected answers relating to hot, concentrated sodium hydroxide, tended only to be seen in higher ability candidate responses and so this tended to be a good discriminator. The weaker candidates were evident from the mentioning of the need for pure oxygen or even potassium dichromate(VI).


(ii) State how the reaction conditions would need to be changed in order to produce sodium chlorate(V) instead of sodium chlorate(I).

(1)

excess sodium hydroxide needed

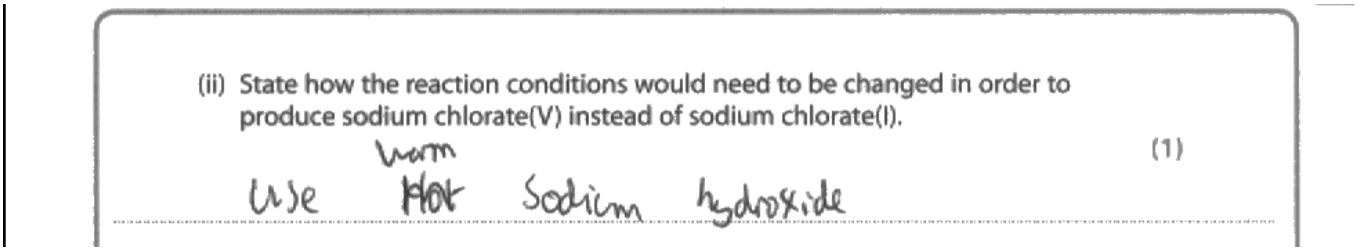
(higher temperature)

ResultsPlus
Examiner Comments

The molar ratio of chlorine to sodium hydroxide is the same in both occasions of disproportionation and so reference to excess was not credited.

ResultsPlus
Examiner Tip

Excess is not the same as more concentrated. Excess can simply mean more volume or mass added but more concentrated means more moles in the same volume.


(ii) State how the reaction conditions would need to be changed in order to produce sodium chlorate(V) instead of sodium chlorate(I).

(1)

use ~~Hot~~ warm Sodium hydroxide

ResultsPlus
Examiner Comments

Warm was not sufficient to score and sadly this candidate has crossed out a correct answer and replaced it with one that didn't score.

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Question 20 (d) (iii)

This question served as a very effective discriminator. Only the more able candidates were able to score. Those likely to gain a grade A could give a correctly balanced equation for both marks. The oxidation number (V) at times confused candidates into thinking that the chlorate had five oxygens but there were also many novel formulae which stretched any chemical justification. Oftentimes equations were not balanced and even a cursory check would have led many to revisit the equation to improve it.

(iii) Give the equation for the reaction between chlorine and sodium hydroxide solution that forms sodium chlorate(V) as one of the products. State symbols are not required.

$3Cl_2 + 2NaOH \rightarrow NaClO_3 + NaCl_2 + 2H_2O$ (2)

ResultsPlus
Examiner Comments

This is an example of a response that was awarded one mark for the correct product but not the second mark because the equation is incorrect.

ResultsPlus
Examiner Tip

Always double-check equations. Surely even a cursory check of this equation would mean that the incorrect formula of sodium chloride would be spotted and this might then result in the remaining mark being gained.

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Question 21 (a) (i)

This question required an understanding of the difference in bond strength between carbon and the halogens, and that the C-F bond is especially strong. This bond strength could be expressed in a number of different ways but it did need to be clear that the carbon-fluorine bond was being referred to. Frequently candidates referred to the high electronegativity of fluorine which is not relevant here and was ignored.

$CH_3CHClF + OH^- \rightarrow CH_3CHOHF + Cl^-$

(i) Suggest why it is unlikely that the fluorine atom in CH_3CHClF would be substituted by the hydroxide ion.

(1)

The C-F bond is very strong

ResultsPlus
Examiner Comments

This is an example of the minimum requirement for the mark.

$CH_3CHClF + OH^- \rightarrow CH_3CHOHF + Cl^-$

(i) Suggest why it is unlikely that the fluorine atom in CH_3CHClF would be substituted by the hydroxide ion.

(1)

because it makes a hydrogen bond and is very electronegative.

ResultsPlus
Examiner Comments

An example here of a commonly-seen response referring to the formation of hydrogen bonding which is totally incorrect.

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Question 21 (a) (ii)

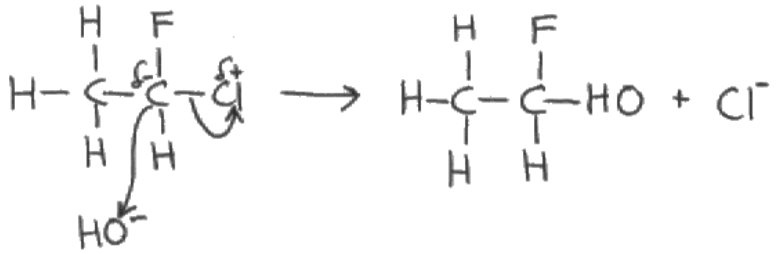
This proved to be an excellent question for discriminating between candidates of differing ability whilst still allowing the weaker candidates to gain some credit.

The question clearly stated that there were a total of 3 errors and occasionally some candidates attempted to find four errors. There was the rare example where the candidate attempted to justify the error in dipoles as two errors, stating that the carbon dipole was wrong for one error and then the chlorine dipole was wrong for the second error. This is in reality a single error and was only awarded one mark.

Another superficial comment which did not gain credit was the claim that the hydroxide ion was drawn the wrong way round, i.e. it should be OH^- and not HO^-. This orientation does not matter in this example and it could be argued that the representation given was the better one because the oxygen was 'facing' the correct direction for the bonding to the carbon of the halogenoalkane.

The example chosen for this question is a primary halogenoalkane and so there is no intermediate carbocation produced. Hence any reference to a carbocation meant that either of the first two marking points was negated.

*(ii) A student attempted to draw the reaction mechanism for the reaction in (a)(i), but made a total of three errors.



Identify these errors and state how they should be corrected.

(3)

First error The carbon should be δ^+ and the chlorine δ^-

Second error The arrow should go from the OH^- to the δ^+

C

Third error The lone pair on the OH^- should be shown.

ResultsPlus
Examiner Comments

The first and second errors are correct and although minimal they are acceptable.

The third error is not creditworthy. The lone pair is not essential in a reaction mechanism because this is what the negative sign represents.

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Examiner Tip

When drawing reaction mechanisms read the question carefully to determine whether dipoles, lone pairs, curly arrows and such are specifically required.

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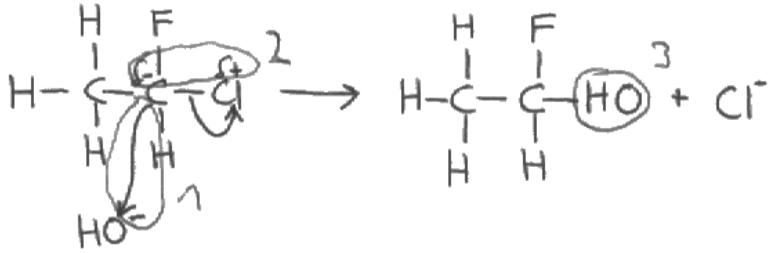
*(ii) A student attempted to draw the reaction mechanism for the reaction in (a)(i), but made a total of three errors.



Identify these errors and state how they should be corrected.

(3)

First error The curly arrow pointing from carbon to the hydroxide ion. The arrow should be flipped and should come from minus sign

Second error The carbon has been labelled δ- and the chlorine δ+. These signs should be switched around.

Third error ~~The carbon in CH_2CFHOH~~ The carbon bonded with the hydroxide ion is shown bonding with the hydrogen and not the oxygen. The carbon must be bonded with oxygen and the hydrogen is bonded to the oxygen.

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Examiner Comments

The first two errors are correctly expressed and gain credit.

In the response for the third error the candidate has referred to the bond of the 'hydroxide ion' to the carbon being drawn the wrong-way round. In the product there is no hydroxide ion and the use of this term was penalised. In the product there is a hydroxyl group and this is the term that should have been used.

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Examiner Tip

Check carefully the expressions used so that an otherwise creditworthy response is not negated by an inappropriate term.

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Question 21 (a) (iii)

The elimination reaction of halogenoalkanes with hydroxide ions in alcoholic solution was aimed at the candidates of higher ability and these were the only ones able to gain any credit. The first mark was awarded for the correct product and the second for the rest of the equation. It was clear from the wide range of organic molecules suggested that this was one area that many candidates are not confident about. Hence it may be appropriate for teachers to focus more attention on this area.

(iii) In hot alcoholic solution, a different reaction may occur between halogenoalkanes and hydroxide ions. alkenes

Write the equation for the reaction between 1-chloro-1-fluoroethane, CH_3CHClF, and hydroxide ions in alcoholic solution.

$CH_3CHClF_{(aq)} + OH^-_{(alc)} \rightarrow H_3C{=}CHF_{(aq)} + HCl_{(aq)}$ (2)

ResultsPlus
Examiner Comments

An example here of the need to check the answer given to avoid simple errors. Note that on the reactant side there is a negative charge but on the product side there are no charges. Hence it can quickly be deduced that this equation does not balance for charge.

In addition there was sufficient space provided here for candidates to draw out their structure in displayed format if desired. If this candidate had done this activity then they would have noted that there was a pentavalent carbon with too many hydrogens. This could then have been quickly remedied and credit been given. In its present form this response was given no credit.

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Examiner Tip

Double-check all equations for elements and for charge. This may highlight specific changes that might be required.

Writing organic structures out in displayed formulae is not always possible but it can be a very useful means of identifying errors in the number of bonds given to particular atoms that might otherwise be missed.

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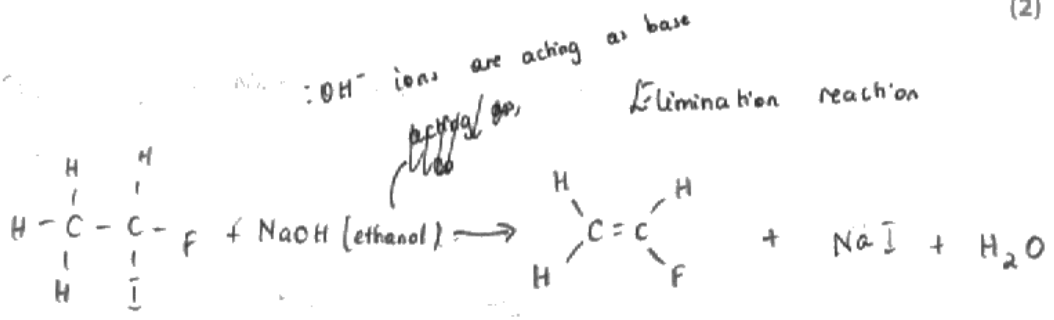
(iii) In hot alcoholic solution, a different reaction may occur between halogenoalkanes and hydroxide ions.

Write the equation for the reaction between 1-chloro-1-fluoroethane, CH_3CHClF, and hydroxide ions in alcoholic solution.

(2)



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Examiner Comments

A correct equation for the elimination reaction of a halogenoalkane but note that this candidate has changed the chlorine atom in the molecule of the question for an iodine atom. It is not acceptable for candidates to 'make up their own question' but because of a single slip this was given one mark out of two.

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Examiner Tip

Double-check to make sure that the molecule in the answer matches the one in the question.

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Question 21 (b)

Reaction flowcharts of this type are common and candidates often write out their own for revision purposes. Hence this question was generally well-answered.

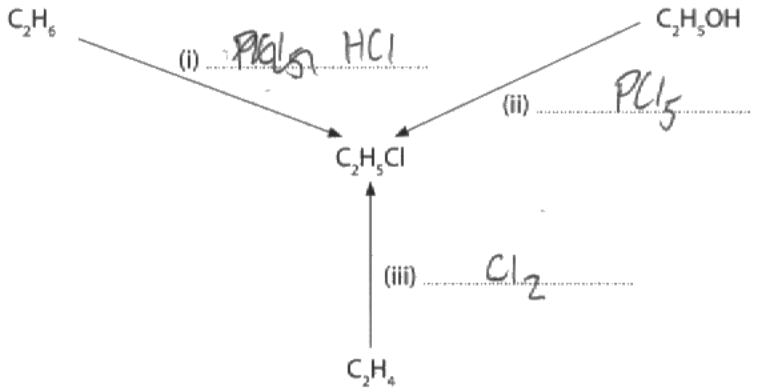
It is well-worth reminding candidates that if reaction conditions are given for this type of question then they must be correct chemically. For example, in part (iii) the reagent HCl or hydrogen chloride is a correct response. However if HCl(aq) is written then this is hydrochloric acid and is not a suitable reagent for converting an alkene into a halogenoalkane. Likewise in part (ii) the expected reagent was phosphorus(V) chloride which is a solid and so any state symbol suggesting a liquid is chemically incorrect and so did not score.

It is also worth reminding candidates the difference between a reagent and an attacking species/intermediate. In part (i) chlorine gas is the reagent and the answer to the question given. Chlorine free radicals are the attacking species and arise from the reagent due to the action of UV light. Hence these species were not given credit but were ignored if they were written alongside the correct response of chlorine gas. The care required with state symbols can be reinforced here because if 'aq' was given with Cl_2 then this negated an otherwise correct response.

The reagent for reaction 1 was the best known while the reagent for reaction 3 was the least well known.

(b) Chloroethane can be produced in various ways as shown below. Identify, by name or formula, the reagent needed for each of these reactions.

(3)



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Examiner Comments

If the candidate had looked at their answer one more time it is likely that the fairly simple errors would have been spotted, For example in order to convert C_2H_4 into C_2H_5Cl in part (iii) the addition of HCl is needed and not Cl_2.

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Examiner Tip

In simple reaction flowcharts like this consider the difference between the product and the reactant as this may indicate the reagent needed or at the very least give a strong suggestion as to what species might be involved.

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Question 21 (c) (i)

Generally a question only answered correctly by the more able candidates. A number of different alternatives were credited, with or without charges. Occasionally the product was given by its molecular formula but this was not awarded the mark because of the ambiguity.

(c) (i) Chloroethane will react with alcoholic ammonia **initially** to produce ethylamine. Complete the equation for this reaction.

(1)

$C_2H_5Cl + NH_3 \rightarrow C_2H_5NH_2 + NH_4Cl$

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Examiner Comments

An example of a response that was somewhat difficult to read but is clearly incorrect anyway. On the product side it is quickly evident that there are two nitrogen atoms but on the reactant side there is only one. Hence this is incorrect. If the response is examined more closely it also appears that in the organic product there are only four hydrogen atoms around the two carbon atoms despite five being drawn in the reactant.

ResultsPlus
Examiner Tip

Responses must be legible to allow the examiner to give credit wherever possible.

(c) (i) Chloroethane will react with alcoholic ammonia **initially** to produce ethylamine. Complete the equation for this reaction.

(1)

$C_2H_5Cl + NH_3 \rightarrow C_2H_5NH_3 + Cl^-$

ResultsPlus
Examiner Comments

Another example where a cursory glance should alert to a missing component in the equation. On the reactant side there are no charges and so on the product side there should either be the same or no overall charge with any charges given being made to cancel. In this response there is only a negative charge on the product side of the equation and so no credit can be given. If a simple '+' had been written by the ethylamine then this equation would have been correct.

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Examiner Tip

Always check equations for charge as well as atoms.

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Question 21 (c) (ii)

A straightforward question with the majority of candidates scoring both marks. Any reference to elimination negated the nucleophilic mark and likewise mention of addition negated the substitution mark.

Question 21 (c) (iii)

There needed to be clear reference to a lone pair of electrons in order to gain the mark for this question. At times there was just mention of an electron pair but this could be a bonded pair. Also the reference to a negative charge was seen but this is not true of the ammonia nucleophile. Furthermore, some candidates seemed to get a bit 'carried away' and referred to lone pairs (plural) which is of course incorrect.

(iii) What feature of the ammonia molecule enables the reaction in (c)(i) to take place?

(1)

unpaired electrons making it a nucleophile.

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Examiner Comments

There is no reference to a pair of electrons here and so this does not score. Use of the plural term 'electrons' could be any number above one.

(iii) What feature of the ammonia molecule enables the reaction in (c)(i) to take place?

(1)

it is a nucleophile

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Examiner Comments

The fact that the molecule is a nucleophile means that the reaction takes place but obviously it is not the feature of the molecule that enables ammonia to react.

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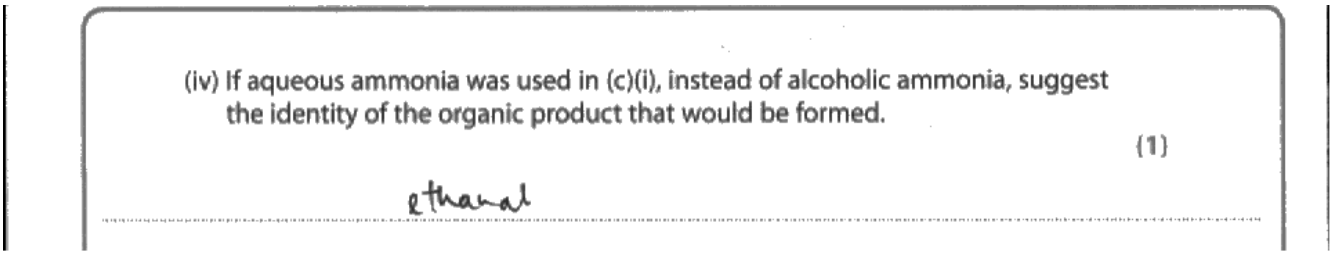
Question 21 (c) (iv)

This was a very effective discriminator at the top end of the ability range. The presence of the hydroxide ion in the equilibrium of aqueous ammonia means that ethanol would be the chemical formed. The weaker candidates tended to miss the instruction in the question that the identity of the organic product was required and so often ammonium chloride was seen.



(iv) If aqueous ammonia was used in (c)(i), instead of alcoholic ammonia, suggest the identity of the organic product that would be formed.

(1)

ethanal

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Examiner Comments

The second vowel is written in exactly the same way as the first and so this reads as 'ethanal' which does not score.

ResultsPlus
Examiner Tip

Care needs to be taken when writing the name of a chemical when there can be confusion between different chemicals. Make sure, particularly with vowels, that it is clear exactly what spelling is meant.

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Question 21 (d) (i)

The full range of scores was seen for this question and so it served as a good indicator of the candidates overall ability. The correct use of dots with the free radicals would have been preferred in all stages but because these were not specifically required in the wording of the question it was decided that it was appropriate to only insist on their presence in the questions where the free radical is either made or 'consumed', namely initiation and termination.

The initiation equation often proved the most problematic equation because of its unfamiliarity and thus if written correctly then more indicative of the more able candidate. One common error was the failure to balance for atoms, with the second fluorine atom in the free radical being missed. Oftentimes the whole CFC molecule was broken into individual free radicals. Where the initiation equation was completed incorrectly the remaining marks could still be scored.

Many propagation stages were seen without any ozone being included despite this being the subject of the question.

The possibilities for the termination equation are many and so credit was given for any sensible and chemically correct products. Hence the formation of Cl_2O from $ClO\cdot$ and $Cl\cdot$ was awarded the mark because dichlorine oxide is a substance that does exist.

(i) Complete the equation for the initiation stage and suggest equations for two of the propagation stages and a termination stage for the mechanism of the reaction that this molecule might undergo with ozone.

(4)

Initiation $CCl_2F_2 \rightarrow CClF_2 + Cl\cdot$

Propagation 1 $Cl\cdot + O_3 \rightarrow ClO\cdot + O_2$

Propagation 2 $ClO\cdot + O_3 \rightarrow Cl\cdot + 2O_2$

Termination $Cl\cdot + Cl\cdot \rightarrow Cl_2$

ResultsPlus
Examiner Comments

A very good attempt here with all equations written correctly for atoms. However note the equation for initiation has the dot of the free radical $CClF_2$ missing and so this response scores 3/4.

ResultsPlus
Examiner Tip

A quick review of equations can identify errors that can easily be remedied.

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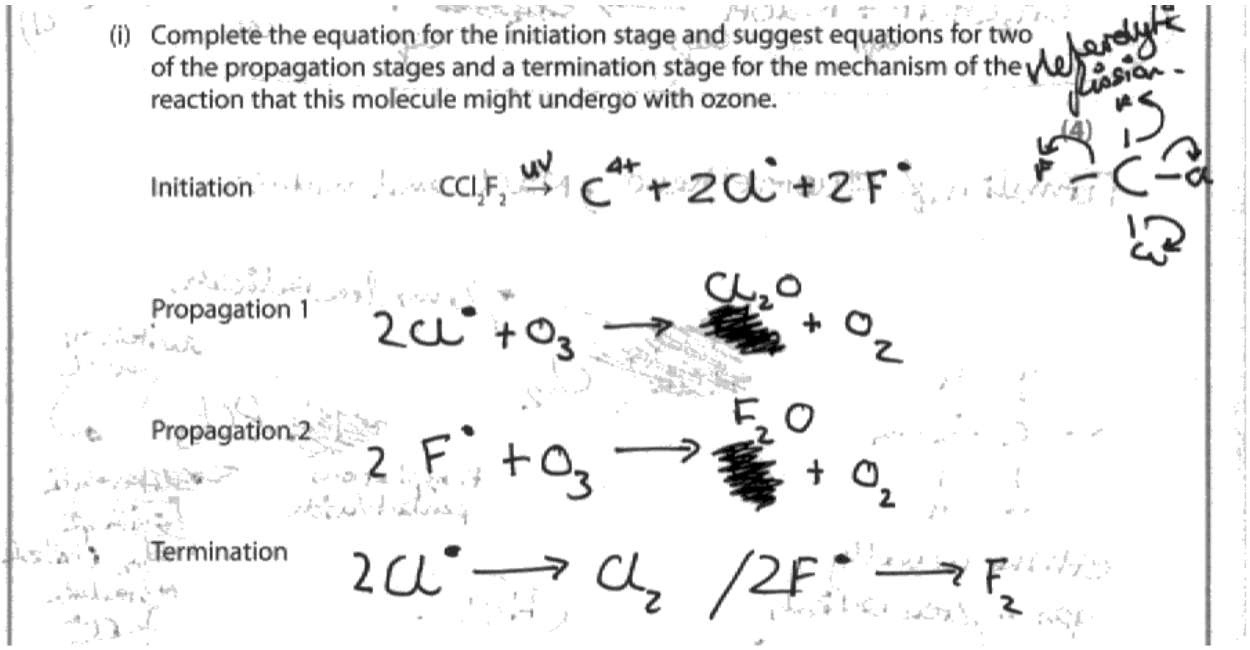
(i) Complete the equation for the initiation stage and suggest equations for two of the propagation stages and a termination stage for the mechanism of the reaction that this molecule might undergo with ozone.



ResultsPlus
Examiner Comments

The initiation and propagation equations are all incorrect. The two termination equations are suitable and so this mark was awarded. However when only one answer or one equation is given then if the candidate gives more than one answer then the list principle applies, namely that if a right and a wrong answer is given then the wrong answer will negate the correct one. In this instance both equations are correct but this practice of multiple answers should be avoided.

ResultsPlus
Examiner Tip

Only give one answer to a question requiring one answer.

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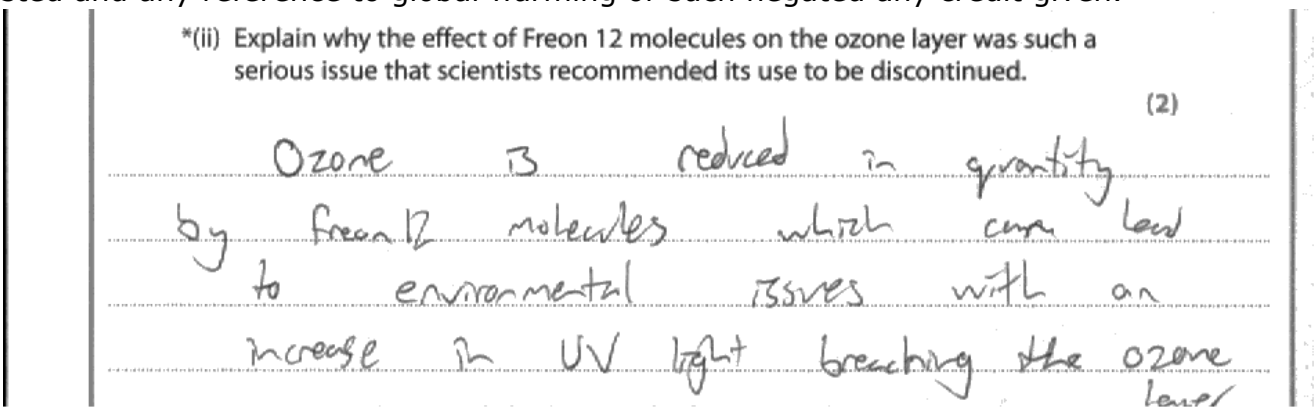
Question 21 (d) (ii)

This is a question that has been asked in a similar way previously and was generally answered in a confident and clear manner. For the first marking point there needed to be clear reference to ultra violet radiation linked to the depletion of the ozone layer. The second mark was commonly scored for the reference to skin cancer but a number of other alternatives were allowed to reflect the other relevant concerns raised.

There was evidence of the 'scatter-gun approach' where every environmental concern was listed and any reference to global warming or such negated any credit given.


*(ii) Explain why the effect of Freon 12 molecules on the ozone layer was such a serious issue that scientists recommended its use to be discontinued.

(2)

Ozone is reduced in quantity by Freon 12 molecules which can lead to environmental issues with an increase in UV light breaching the ozone layer

ResultsPlus

Examiner Comments

The first mark for the depletion of the ozone layer and the increase in uv light was awarded here but there is no reference to why this is such a serious issue and so does not score the second mark.

ResultsPlus

Examiner Tip

Make sure that if there are multiple marks for a response that multiple points are made in the answer to address all of the requirements of the question asked.

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*(ii) Explain why the effect of Freon 12 molecules on the ozone layer was such a serious issue that scientists recommended its use to be discontinued.

(2)

Because it continued to create chlorine ions which could continually regenerate, depleting the ozone layer.

ResultsPlus
Examiner Comments

The idea of the regeneration of the chlorine is correct but obviously the species is a chlorine free radical and not a chloride ion. Hence this was not awarded any credit.

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Question 21 (d) (iii)

This was also a familiar question, having been previously asked in 2012 and consequently usually well-answered. The first mark needed to clearly refer to the absorption of infrared radiation and this was frequently awarded. However the second mark for the acknowledgement that this infrared radiation was that from the earth's surface was not so common and tended to be seen by only the more able. Use of the phrase 'back to the earth' was given credit because the use of the word back means that the radiation must have come from there in the first place.

However as in (d)(ii) there was the occasional confusion with ozone destruction and any reference to uv or ozone resulted in no marks.

(iii) Freon 12, CCl_2F_2, could also be described as a "greenhouse gas". Explain what the term 'greenhouse gas' means.

(2)

Greenhouse gas is are gases such as water vapour, carbon dioxide and methane which contribute to the increase of global morning.

ResultsPlus
Examiner Comments

This response correctly gives a list of a number of greenhouse gases but fails to describe what one actually is. Hence this response does not score.

ResultsPlus
Examiner Tip

Make sure that the question asked is the one that is actually being answered.

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Question 21 (d) (iv)

A more stretching question in which only the more able candidates were able to get the mark. Most candidates seemed to be aware only of the damage that CFCs inflict on the ozone layer and not that they are extremely effective at absorbing infrared radiation, in fact often many thousand times more so than carbon dioxide. However it is their concentration in the atmosphere that is the crucial factor and it was pleasing to note that some well-prepared candidates were aware of this. Alternatively the concept of residency time could have been explained and this was seen by some very able candidates.

(iv) Freon 12, and other similar molecules, are not normally viewed as contributors to the greenhouse effect. Suggest why this is so.

(1)

as they do not have a very large input compared to CO_2.

ResultsPlus
Examiner Comments

While it is true that CFCs do not have a large input in comparison to carbon dioxide this does not address 'why' this is the case. Hence this does not score.

(iv) Freon 12, and other similar molecules, are not normally viewed as contributors to the greenhouse effect. Suggest why this is so.

(1)

Because it does not trap heat back to the earth, but rather ~~deplet~~depletes its ozone layer.

ResultsPlus
Examiner Comments

This is an example of a type of response commonly seen where the candidate seems convinced that CFCs only deplete ozone and can have no effect on global warming. Hence this response does not score.

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Question 22 (a)

This was a high-scoring question that was accessible to all, requiring a straightforward equation. Occasionally the formula Mg_2Cl_4 was given which was understandable, given the information in the passage, and so if included in a balanced equation then one mark out of two was allowed.

(a) Complete and balance the equation for this reaction. State symbols are not required.

(2)

Mg_2Si + 2 HCl ⟶ 2 MgCl + SiH_4

ResultsPlus

Examiner Comments

It is expected at this level that candidates can write the correct formula of magnesium chloride. Hence this response does not score.

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Question 22 (b)

Another high-scoring question which allowed the whole ability range to gain credit. The question required the application of the familiar combustion equation for carbon to that of silicon and it was pleasing to see the large number of correct responses. However, candidates do need to be alert to the words that they are writing and the actual substances that they mean as is evident from the examples below.

(b) Bubbles of silane rise to the surface in the reaction mixture and spontaneously combust with oxygen in the air.

Suggest the names or formulae of the products of the reaction between silane and oxygen. $SiH_4 + O_2 \rightarrow SO_2 + 2H_2$

(2)

Silicon dioxide and hydrogen

ResultsPlus
Examiner Comments

Care needs to be taken here because there is also an equation written in the space provided and because the wording of the question allows for names or formulae this must also be taken into account. Hence there were occasions where the correct name was negated by an incorrect formula and in this instance the formula of the product is sulfur dioxide and not silicon dioxide.

ResultsPlus
Examiner Tip

If a question asks for names or formulae then do not give both as both must be correct if given. Choose one or the other.

(b) Bubbles of silane rise to the surface in the reaction mixture and spontaneously combust with oxygen in the air. $SiH_4 + O_2$

Suggest the names or formulae of the products of the reaction between silane and oxygen.

(2)

SiO_2, H_2O, SiO, SiO_3, O_2, H

ResultsPlus
Examiner Comments

This is an example where the 'list principle' is applied and so although the first two answers are correct, the subsequent answers negate any marks that could have been awarded.

ResultsPlus
Examiner Tip

Be guided by the mark allocation for the question and/or the wording given. If there are two marks available then it is likely that two points or substances in this case, are required.

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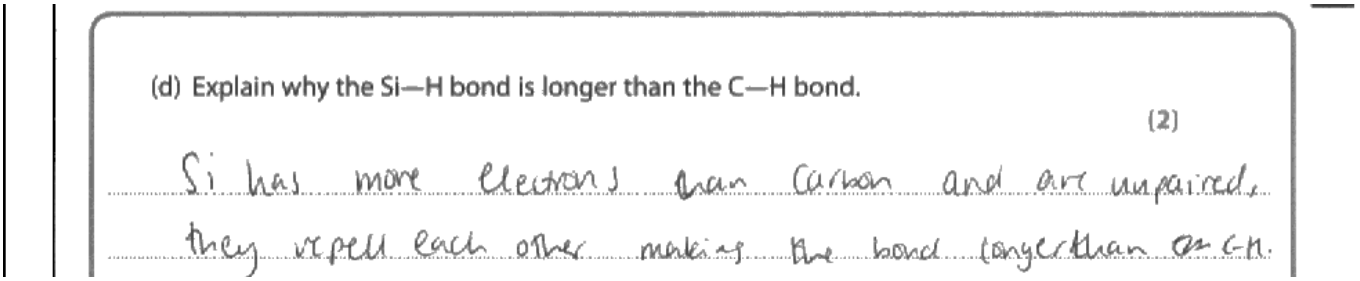
Question 22 (c)

A straightforward question for which the majority of candidates were awarded both marks. A small minority of candidates seemed unsure and so gave bond angles which didn't match the shape, presumably in an attempt to cover two possibilities and thus score one mark out of two.

Question 22 (d)

Most candidates were able to score the first mark, often referring to the larger atomic radius of silicon or that silicon has one more shell of electrons. However the second key principle of 'more shielding' by this extra inner electron shell was rarely seen. A suitable alternative for the second mark was the consequence of the large atomic radius, namely that there would be weaker attraction for the shared electron pair and this was seen rather more often but neither option was common. In addition erroneous reference to ions and ionic radius were seen.


(d) Explain why the Si—H bond is longer than the C—H bond.

(2)

Si has more electrons than Carbon and are unpaired, they repell each other making the bond longer than a C-H.

ResultsPlus

Examiner Comments

This is an example of an answer which simply referred to silicon having 'more electrons' without specifying that a whole additional shell of electrons is the actual difference. Hence this did not score.

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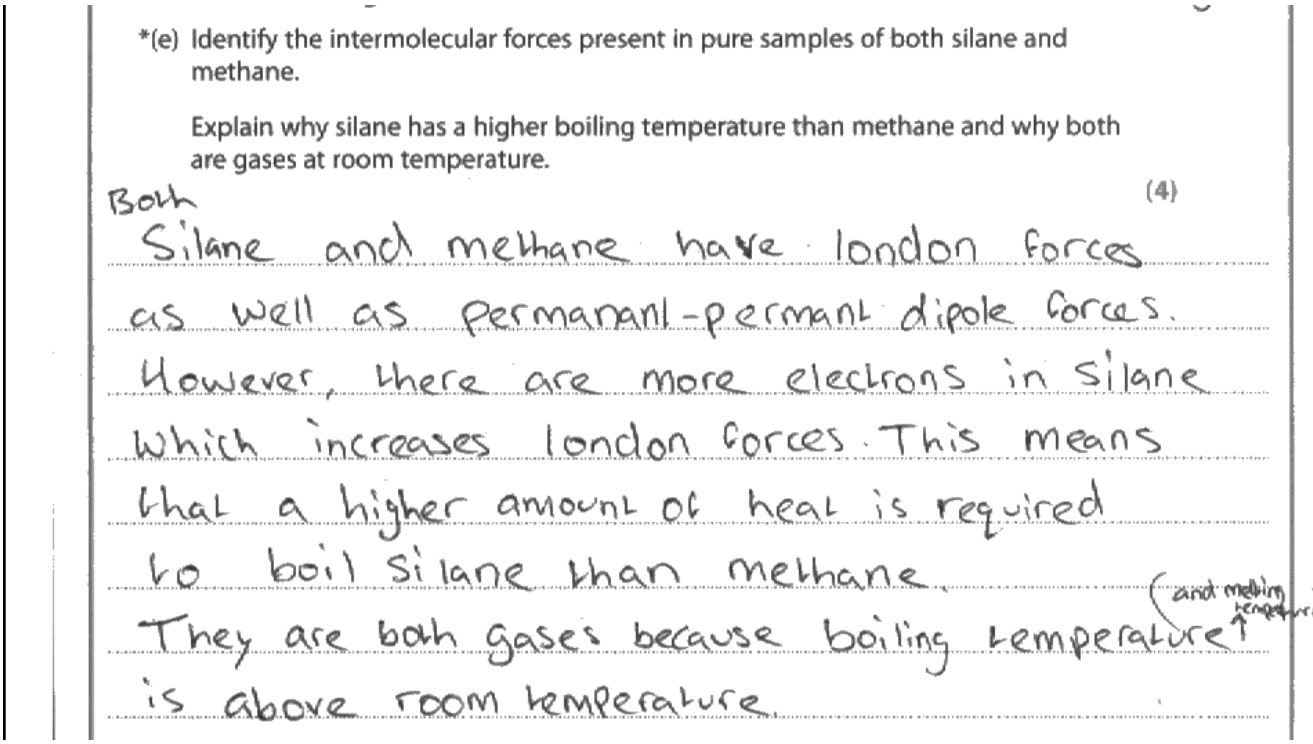
Question 22 (e)

This was generally a high-scoring question and many 4/4 responses seen. There were two common reasons why a significant number of candidates scored 3 out of the 4 marks. It appeared that the candidate missed/forgot the second part of the question relating to why silane and methane are both gases at room temperature. The second common error was to state that silane had permanent dipole-dipole intermolecular forces as well as London forces. This statement negated the first marking point but the remaining three marking points could, and often were, still awarded. In addition the misuse of expressions such as 'electron cloud' or 'electron density' were seen frequently.

A considerable number of candidates went beyond the space allocated because they explained why hydrogen bonding or dipole-dipole interactions were not present. However this was not necessary and candidates are always best advised to plan their response and match it to the space provided.



*(e) Identify the intermolecular forces present in pure samples of both silane and methane.

Explain why silane has a higher boiling temperature than methane and why both are gases at room temperature.

(4)

Both
Silane and methane have london forces as well as permanent-permant dipole forces. However, there are more electrons in Silane which increases london forces. This means that a higher amount of heat is required to boil Silane than methane. (and melting temperature)
They are both gases because boiling temperature is above room temperature.

ResultsPlus
Examiner Comments

This response is an example where the first marking point is lost due to the reference to permanent dipole-dipole interactions. In addition the statement that the substances are gases because they have low boiling points is insufficient as an explanation and so does not score. Hence this response was awarded two marks out of four.

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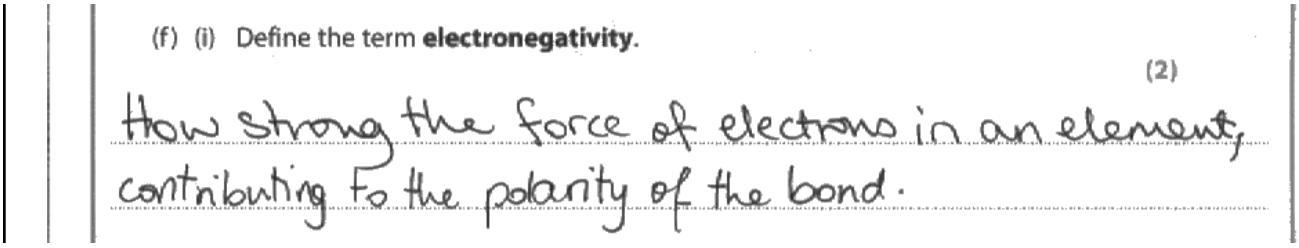
Question 22 (f) (i)

Definitions should be relatively easy marks to gain but there were a plethora of errors seen in the thousands of responses to this question. A significant minority, for example, referring to the attraction an atom has for one electron and this did not score, neither did those who referred to the attraction of lone pairs of electrons. There was also reference made on occasion to the gaining of electrons but this is ionic bonding.


(f) (i) Define the term **electronegativity**.

(2)

How strong the force of electrons in an element, contributing to the polarity of the bond.

ResultsPlus
Examiner Comments

It is not clear in this response exactly what force is being referred to and neither is it clear which electrons are involved in this 'force'. Hence this was not awarded any marks.

ResultsPlus
Examiner Tip

Most atoms have inner shells of electrons and often not all of the electrons in the outer shell are involved in any bonding so the response must be very clear exactly which electrons are being referred to.

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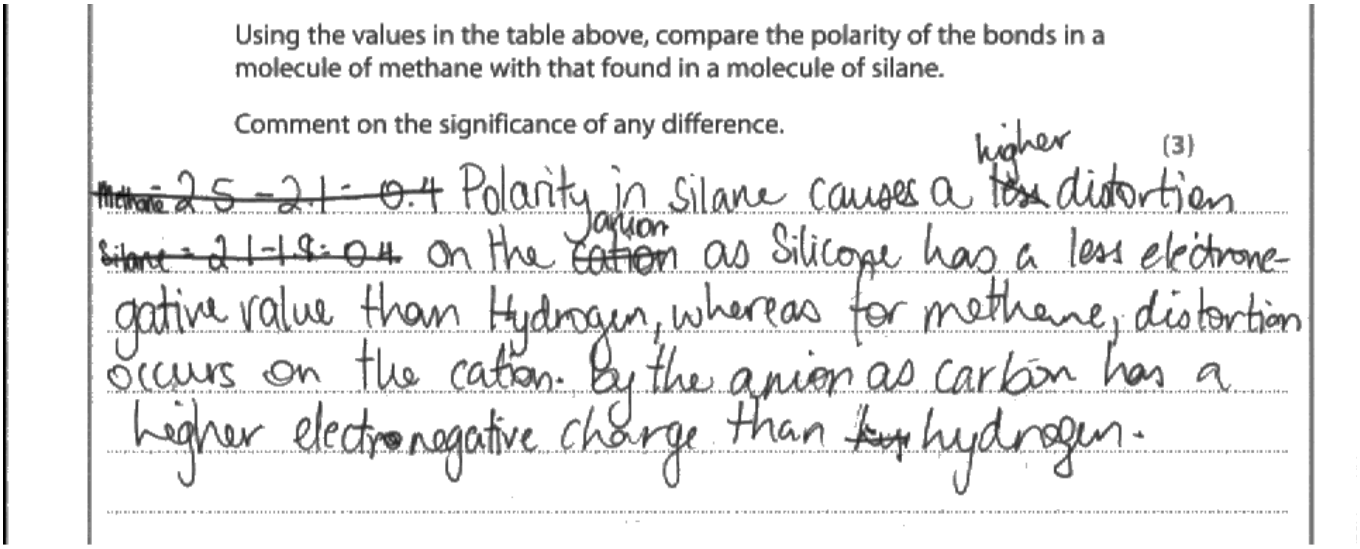
Question 22 (f) (ii)

Unfortunately candidates often wrote excessively on this question which led to many answers extending well beyond the answer space provided. The question began by requiring candidates to calculate the polarity of the bonds in silane and methane and compare them. This activity could have easily been completed in three of the lines given. The remaining demand of the question related to the significance of the difference and was attempting to get candidates to connect the fact that both substances are well known as 'non-polar' and yet there are differences in electronegativity. Only the more able candidates were able to realise that this meant that the difference in electronegativity is so small that it is insignificant.



Using the values in the table above, compare the polarity of the bonds in a molecule of methane with that found in a molecule of silane.

Comment on the significance of any difference. (3)

~~Methane 2.5 - 2.1 = 0.4~~ Polarity in Silane causes a higher ~~less~~ distortion ~~Silane = 2.1 - 1.8 = 0.4~~ on the ~~cation~~ anion as Silicone has a less electronegative value than Hydrogen, whereas for methane, distortion occurs on the cation. By the anion as carbon has a higher electronegative charge than ~~by~~ hydrogen.

ResultsPlus
Examiner Comments

Unfortunately this response refers to ions, both anions and cations which is completely incorrect. In addition there is no numerical calculation of the polarity difference.

Also note that silane changes to silicone half way through and so this response did not score.

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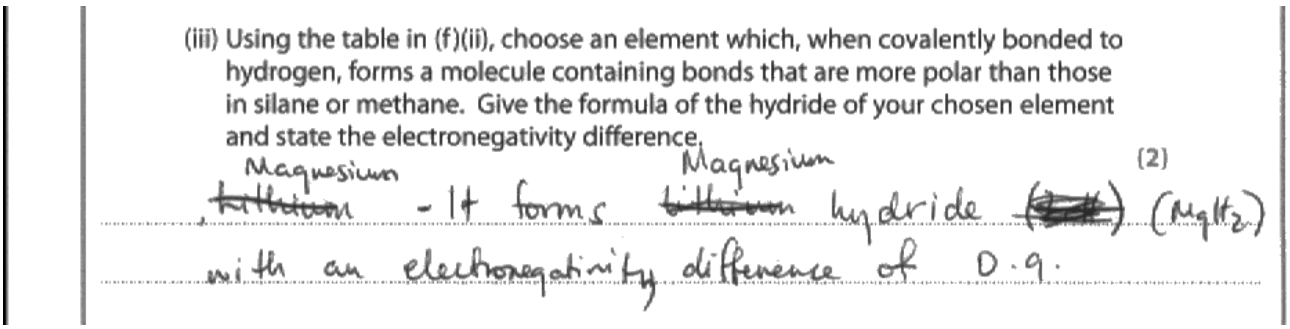
Question 22 (f) (iii)

This was a well-answered question with the majority of candidates gaining credit with the chosen example of HF and the electronegativity difference of 1.9. Occasionally other correct examples were seen and credited. Rare errors seen were the failure to give the formula of the hydride example despite this being specifically required in the question or the formula given was an incorrect one such as HF_2. A small minority of candidates gave a metallic hydride even though the opening line of the question stated that a covalently bonded example was needed.



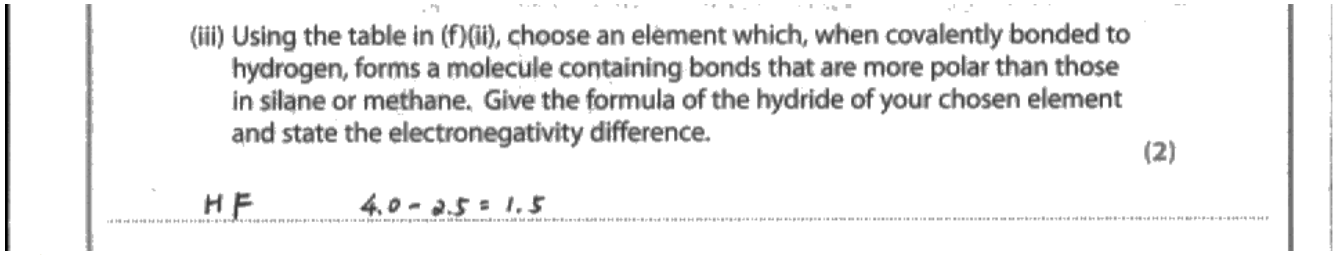
(iii) Using the table in (f)(ii), choose an element which, when covalently bonded to hydrogen, forms a molecule containing bonds that are more polar than those in silane or methane. Give the formula of the hydride of your chosen element and state the electronegativity difference.

(2)

~~Magnesium~~ ~~lithium~~ - It forms Magnesium ~~lithium~~ hydride ~~(MgH)~~ (MgH_2) with an electronegativity difference of 0.9.

ResultsPlus
Examiner Comments

This is an example of a response which has missed the requirement in the first line of the question for a covalently bonded example, either that or the true bonding nature of metal hydrides is misunderstood. As long as the formula of the metal hydride was given correctly and the correct electronegativity difference given then one mark out of two was awarded. This is the case here.



(iii) Using the table in (f)(ii), choose an element which, when covalently bonded to hydrogen, forms a molecule containing bonds that are more polar than those in silane or methane. Give the formula of the hydride of your chosen element and state the electronegativity difference.

(2)

HF 4.0 - 2.5 = 1.5

ResultsPlus
Examiner Comments

This response was awarded one mark for the formula of a suitable hydride. However although the subtraction is correctly done the value for hydrogen is 2.1 and not 2.5 and so this mark was not given.

ResultsPlus
Examiner Tip

Double-check the values used from a data source to ensure that the ones selected are the actual ones needed.

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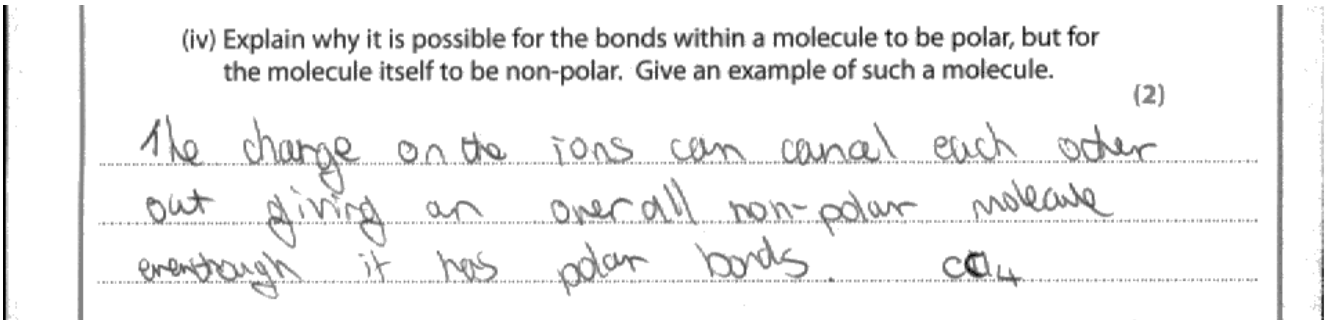
Question 22 (f) (iv)

The polarities in a molecule do cancel by their very nature but it is the molecular shape that can mean the polarities cancel such that the molecule is non-polar. It is this aspect of the symmetry of the molecule that was required for the first marking point and this tended to distinguish candidates of good ability and above.

Almost all examples given were suitable since in the context of the question methane and silane were allowed. However very occasionally examples of diatomic molecules were seen or even ionic compounds such as sodium chloride.

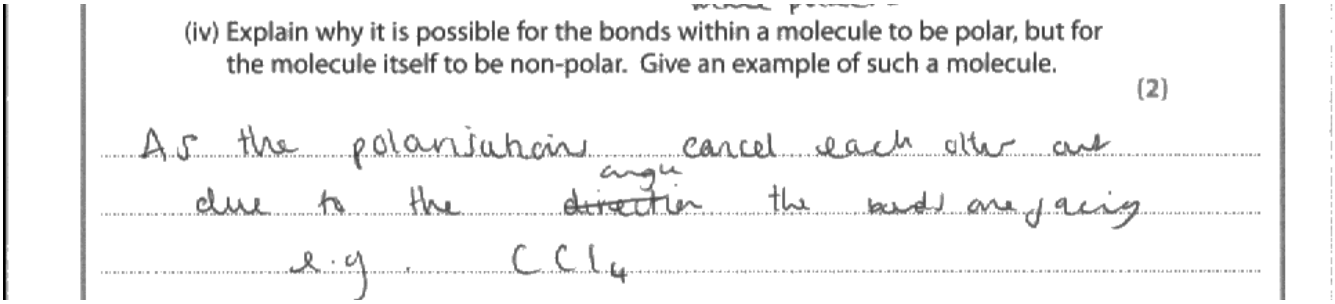

(iv) Explain why it is possible for the bonds within a molecule to be polar, but for the molecule itself to be non-polar. Give an example of such a molecule.

(2)

The charge on the ions can canal each other out giving an overall non-polar molecule eventhough it has polar bonds. CCl_4

ResultsPlus
Examiner Comments

This is another example where the word choice of the candidate is incorrect. In tetrachloromethane the atoms have polarity but are not ions. The mark for a suitable example was awarded.


(iv) Explain why it is possible for the bonds within a molecule to be polar, but for the molecule itself to be non-polar. Give an example of such a molecule.

(2)

As the polarisation cancel each other out due to the ~~direction~~ angle the bond are facing e.g. CCl_4

ResultsPlus
Examiner Comments

An example of an 'almost there' answer. Reference to the polarities cancelling due to the angle is unclear unless the angle is explained or illustrated. Hence only the mark for the suitable example was awarded.

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Paper Summary

A number of key points should be highlighted to students and emphasized by teachers in their teaching of this subject;

- Double-checking and even triple-checking is an absolute must. A large number of candidates would have improved their overall score if even only 5 minutes had been effectively spent on such activity.
- Equations must always balance for atoms and charge. This is a simple way of checking that the answer given is likely to be correct.
- Chemical terms must be used with care and precision. Sometimes the use of a familiar term such as ion, in an inappropriate context will negate an otherwise correct response.
- Avoid the so called 'scatter-gun approach' where everything that is known about a subject is written or a list of possibilities is written, with the hope that something is correct.
- Make sure that any units given are correct. If they are not asked for then do not give them.
- Let the space provided for the response give guidance as to the depth and extent of answer required.
- Read the requirements of the question carefully to ensure that the precise needs are met.

Grade Boundaries

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