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Examiners' Report
June 2013

GCE Chemistry 6CH02 01

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Introduction

This paper provided opportunities for the whole-ability range to demonstrate their knowledge and understanding. There was no evidence of candidates 'running out of time' and any blank spaces were due to a lack of understanding of what was required rather than there being a shortage of time to attempt the question.

The successful candidates were able to:

- apply their knowledge and understanding to the context of the question set, for example stating that a sample would need to be divided into separate portions for repeats to be possible or how the addition of an acid to a system in equilibrium would affect the position of equilibrium;
- recall and explain practical details in relevant examples, such as the type of solvent required for a particular reaction and how group 2 carbonates would differ in their thermal decomposition;
- correctly complete calculations all the way through to the end, keeping in mind the units involved and using the appropriate significant figures.

The less successful candidates were unable to:

- express themselves clearly enough to effectively make the point required, such as when explaining the hydrogen bonding results in a higher-than-expected boiling temperature;
- write in a legible way that could be easily understood;
- include crucial details such as a state symbol or the different colours that would be observed in a colour change.

Question 21 (a) (b)

A sizeable minority of candidates seemed unaware that barium is a group 2 element from the formulae of some of the compounds that were given, for example BOH. They could possibly be reminded that there is a copy of the periodic table at the back of the paper. It was not uncommon to see BaO as a product or a barium compound without any hydrogen being produced. State symbols were sometimes missing from one of the four species and so the second mark was not awarded. In addition a significant number gave $H_2O(aq)$ as a reactant.

On the basis of only penalising an error once there were opportunities of transferred error in parts (a)(ii) and (b) from an incorrect barium compound in (a)(i). In this particular situation the consequence of transferred error did seem to make the equation required for (b) somewhat easier but balancing of the equation was still required.

The part (a)(ii) question on oxidation numbers was generally answered well but many candidates focussed their efforts solely on the barium and giving the oxidation change of this element. Candidates should always appreciate the number of marks allocated to a particular question and it is unlikely that two marks would be given for two oxidation numbers. In addition a proper understanding of the concept behind oxidation numbers should prompt a candidate that if one element is oxidised and the oxidation number goes up, then there needs to be another species which is reduced and where the oxidation number goes down.

21 (a) (i) An alkaline solution is produced when barium reacts with cold water. Write the equation for this reaction, including all state symbols.

$Ba(s) + 2H_2O(l) \rightarrow Ba(OH)_2(aq) + H_2(g)$ **(2)**

(ii) The reaction in (a)(i) is a redox reaction. State the initial and final oxidation number of any element that changes its oxidation number.

i.e. Ba(s) **(2)**

Barium from 0 to 2+ in $Ba(OH)_2(aq)$

(b) Dilute hydrochloric acid is added to the solution produced in (a)(i). Write the equation for the reaction which occurs. State symbols are **not** required.

$Ba(OH)_2 + 2HCl \rightarrow BaCl_2 + 2H_2O$ **(1)**

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Examiner Comments

This candidate has clearly expressed the state symbols in part (a)(i) which is important as an 's' and a 'g' can be difficult to distinguish at times. The equation is balanced and so scores both marks.

In part (a)(ii) this is an example of a candidate who appears to know exactly what is going on but has only given the information for the element, barium, experiencing an increase in oxidation number. Hence this will only score one mark out of two.

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Examiner Tip

Read the question carefully to ensure that all the marking points are addressed. In this question it clearly asks for the candidate to state 'any element that changes its oxidation number' and so this can be both a decrease as well as an increase.

Question 21 (c)

Most candidates correctly gave the observation that a white precipitate was formed. However a significant number omitted the colour 'white' and so did not score. In addition a sizeable number of candidates referred to the solution going cloudy or forming a suspension, which also failed to score.

The second marking point was for an explanation for this appearance. As a minimum the candidate needed to explain that the barium sulfate produced from the addition of sulfuric acid was insoluble. The able candidates did do this while others gave the solubility trend going down group 2 as if it was something that had been learnt by rote instead of applying the knowledge to the question asked.

(c) Dilute sulfuric acid is added to another sample of the solution produced in (a)(i). How would the appearance of the resulting mixture differ from the mixture produced in (b)? Explain this difference.

(2)

Appearance white precipitate

Explanation because barium sulphate $BaSO_4$ formed is not soluble in water whereas $BaCl_2$ formed in (b) is soluble in water.

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Examiner Comments

This candidate has given an excellent answer stating not only that the barium sulfate is insoluble and so will be evident as a white precipitate but also that barium chloride by contrast is soluble.

Question 21 (d)

The evidence from scripts is that the candidates answered the questions as intended. Credit for both parts (i) and (ii) was accessible in either place on the paper to ensure that candidates were not disadvantaged.

In part (i) the thermal stability trend of group 2 carbonates was generally well known but some candidates referred to the metals 'barium' and 'magnesium' rather than their respective carbonates. Certainly precision in expression is vital for success in examinations. In addition the stem of the question stated that practical details were not required but a sizeable number of responses gave descriptions of bubbling through limewater etc. which was not wrong but would have taken unnecessary time. It was a little surprising that a significant number of equations for the thermal decomposition of carbonates included oxygen either as a reactant or a product. Occasionally $Mg(CO_3)_2$ was seen.

In part (ii) the flame tests were also well known with the vast majority recognising barium producing a green flame. However, it was disappointing to see 'bright' or 'white' for the result with magnesium carbonate so often in the candidates' answers. Presumably the result with the metal was envisaged rather than the actual result with the carbonate.

(d) (i) Two white powders are known to be barium carbonate and magnesium carbonate.

How could you distinguish between the two powders by heating them?
[No practical details are required.]

Include the equation for the action of heat on one of these carbonates. State symbols are not required.

(2)

By heating the two powders seperately, and testing any gas evolved using limewater, you can determine which is the magnesium by which compound releases CO_2. Mg will decompose to form CO_2, whereas Ba will not.

Equation:

$MgCO_3 \rightarrow MgO + CO_2$

(ii) Suggest another test, other than heating or the use of an acid, which could be used to distinguish between magnesium carbonate and barium carbonate. State the results for both compounds.

(2)

Test Flame test

Result with magnesium carbonate a yellow flame would be seen,

Result with barium carbonate A green flame would be seen.

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Examiner Comments

This is an example where the candidate in part (i) has stated that magnesium alone will decompose to give carbon dioxide, instead of the compound magnesium carbonate.

In part (ii) the answer for the flame with magnesium which gained credit was either colourless or clear. Remember that sodium metal ions can be said to give a yellow colour and so the answer here is incorrect. One mark was awarded however for the correct colour of the barium flame.

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Examiner Tip

Lack of precision like this can result in the loss of valuable marks and ultimately a drop in grades so candidates should take extra care that their answers clearly refer to the substance that they actually mean.

Question 22 (a) (i)-(iii)

These parts were high scoring and demonstrated good understanding by most candidates. However, a common error in part (i) was to state "ethanoic" instead of "ethanolic". Other errors frequently seen were 'high pressure' and 'heat under reflux'.

22 (a) The products of the reaction when 2-chlorobutane is heated with sodium hydroxide depend on the conditions.

(i) What condition, other than a suitable temperature and sodium hydroxide concentration, would produce a mixture of but-1-ene and but-2-ene?

(1)

Presence of ethanol to act as a solvent.

(ii) What type of reaction occurs in (a)(i)?

(1)

Elimination

(iii) What condition, other than a suitable temperature and sodium hydroxide concentration, would produce butan-2-ol in the reaction of 2-chlorobutane with sodium hydroxide?

(1)

Heat under reflux

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Examiner Comments

Parts (i) and (ii) are fine but part (iii) is perhaps a 'stock answer' referring to the use of reflux which does not score. The stem of the question clearly states that something other than temperature is required but it seems that this was not noted.

22 (a) The products of the reaction when 2-chlorobutane is heated with sodium hydroxide depend on the conditions.

(i) What condition, other than a suitable temperature and sodium hydroxide concentration, would produce a mixture of but-1-ene and but-2-ene?

(1)

Whether or not the NaOH is alcoholic, if ethanol or another alcohol is present, then those products will be formed

(ii) What type of reaction occurs in (a)(i)?

(1)

Elimination

(iii) What condition, other than a suitable temperature and sodium hydroxide concentration, would produce butan-2-ol in the reaction of 2-chlorobutane with sodium hydroxide?

(1)

~~The presence~~ whether or not the sodium hydroxide is in solution

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Examiner Comments

The space of a single line for an answer should suggest that the answer required is brief. Here the candidate has written more than is required for parts (i) and (iii) and the danger is that any additional comments could negate the correct response.

In part (iii) the reference to solution is not sufficient since the point of the question is that the hydroxide ions have a different effect depending on the solvent used and so simple reference to solution rather than the nature of the solution did not result in the mark being awarded.

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Examiner Tip

Take note of the space provided for the answers to questions. If there is only one line given then the answer will be simple. If multiple lines are provided then a more in-depth answer is required; although sometimes more lines are provided to enable space for corrections to answers.

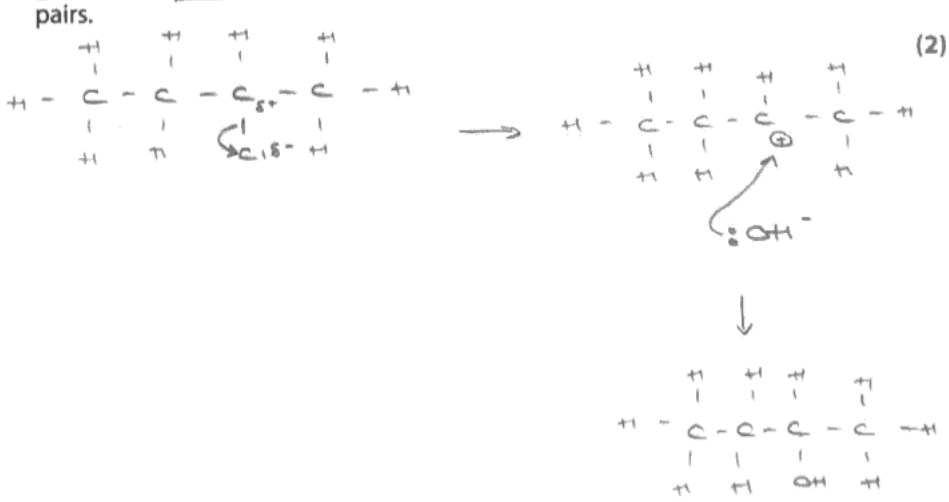
Question 22 (a) (iv)

The mechanism was fairly well-known but by far the most common score was 1 out of 2 due to errors which would have been easy to correct, as seen in the two examples below. Another common error was a lack of a charge on the transition state if drawn; this was not essential but if drawn it had to be correct.

Considerable latitude was allowed for the curly arrow coming from the hydroxide ion since legitimately it could come from the negative charge or a lone pair if drawn. However the head of the two curly arrows did need to be much more carefully placed. The curly arrow from the hydroxide ion needed to clearly go to the carbon with the chlorine attached and the other curly arrow needed to go from the C-Cl bond to the chlorine.

(iv) Suggest the mechanism for the reaction of 2-chlorobutane with hydroxide ions to form butan-2-ol. Use curly arrows to show the movement of electron pairs.

(2)



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Examiner Comments

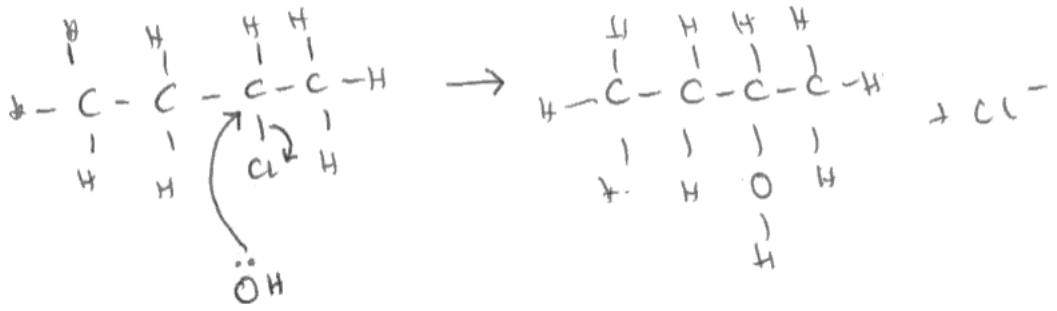
Very nicely drawn reaction mechanism with clear curly arrows but note the sudden disappearance of the chlorine. This resulted in the loss of one mark and was by far the most common error.

ResultsPlus
Examiner Tip

Candidates should check and double-check to make sure that 'silly little errors' like this have not been made.

(iv) Suggest the mechanism for the reaction of 2-chlorobutane with hydroxide ions to form butan-2-ol. Use curly arrows to show the movement of electron pairs. substitution nucleophilic

(2)



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Examiner Comments

The curly arrow from the OH to the carbon with the chlorine is fine but note that the OH does not have a charge. This omission resulted in the loss of the mark.

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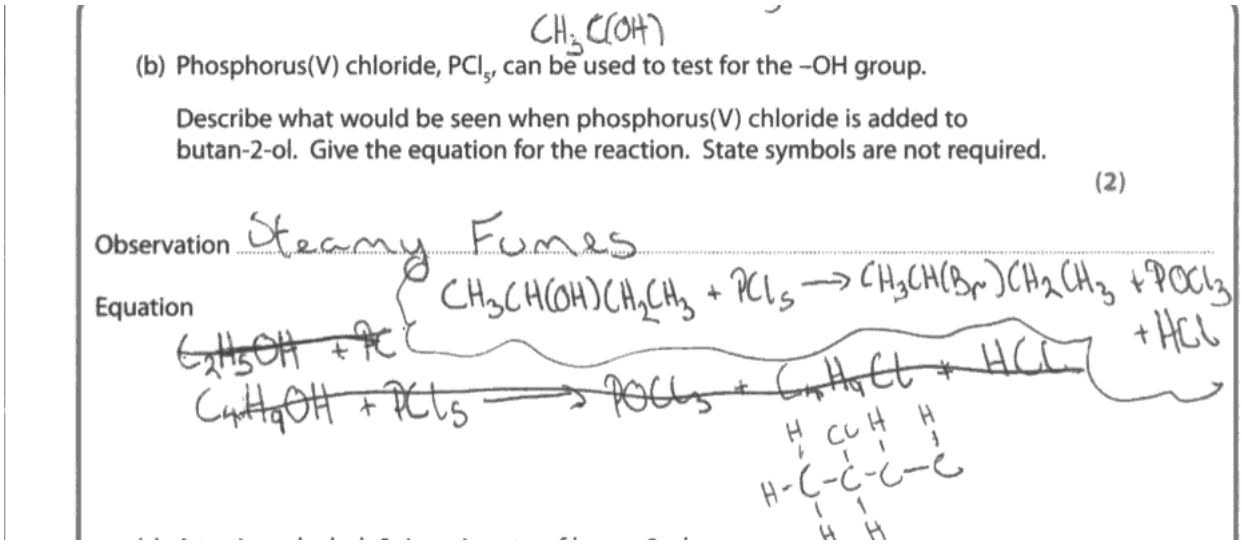
Examiner Tip

Check that charges are where they need to be.

Question 22 (b)

This was a high-scoring question with the vast majority scoring both marks. This seems to be a test which is well-known and even the possibly tricky $POCl_3$ presented few problems. There was the occasional molecular formula given for the halogenoalkane but this was very rare and did not gain credit.



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Examiner Comments

This candidate obviously had to re-write their answer in order to get it right. Crossed-out work is OK as long as the answer which is requiring marking is clear and this is the case here. However if the organic product is carefully checked the halogen has suddenly become bromine but both of the phosphorus substances have chlorine. This is a different substance from that produced and so will not score the equation mark.

The observation mark still scores one mark.

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Examiner Tip

Candidates should check every detail to make sure that they have not made elementary mistakes!

Question 22 (c) (i)-(iii)

Part (i) was a also a high-scoring question but at times candidates again lost marks for lack of precision in their answers. For example, 'no reaction' was allowed because this is itself an observation but to state as an answer 'no observation' is clearly incorrect. The fact that there is no reaction or no change is an observation.

Part (ii) presented more difficulty since the structural formula was asked for but the wiser students often drew out the displayed formula as their working and then correctly gave the structural formula. Pentavalent carbons were not that common but were seen.

Part (iii) also highlighted the need for careful choice of words in answering questions. Many candidates identified the presence of the -OH group but failed to state HOW the presence would be identified. Secondly, it is the O-H bond which is the key point here and simple reference to the OH group or the ketone group was insufficient to score. There needed to be explicit reference to the bond involved, although this could be drawn, as in C=O. In addition a sizeable minority got confused with mass spectrometry and incorrectly referred to molecular fragments.

(c) A tertiary alcohol, **A**, is an isomer of butan-2-ol.

(i) Butan-2-ol and **A** can be distinguished by warming separate samples with a mixture of potassium dichromate(VI) and sulfuric acid. State the observations which would be made with each alcohol.

(2)

Observation with butan-2-ol: butan-2-ol will be oxidized from green to orange

Observation with **A**: as A is an tertiary alcohol nothing will change the solution will stay orange.

(ii) Give the structural formula of the organic product which forms when butan-2-ol is oxidized.

(1)

~~CH_3CH_2C~~

$CH_3CH{=}OCH_2CH_3$.

(iii) Explain how infrared spectroscopy could be used to detect whether butan-2-ol has been oxidized.

(1)

By displaying the -OH- group spec on the Spectroscopy graph. The bold distictive Spec line will represent -OH.

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Examiner Comments

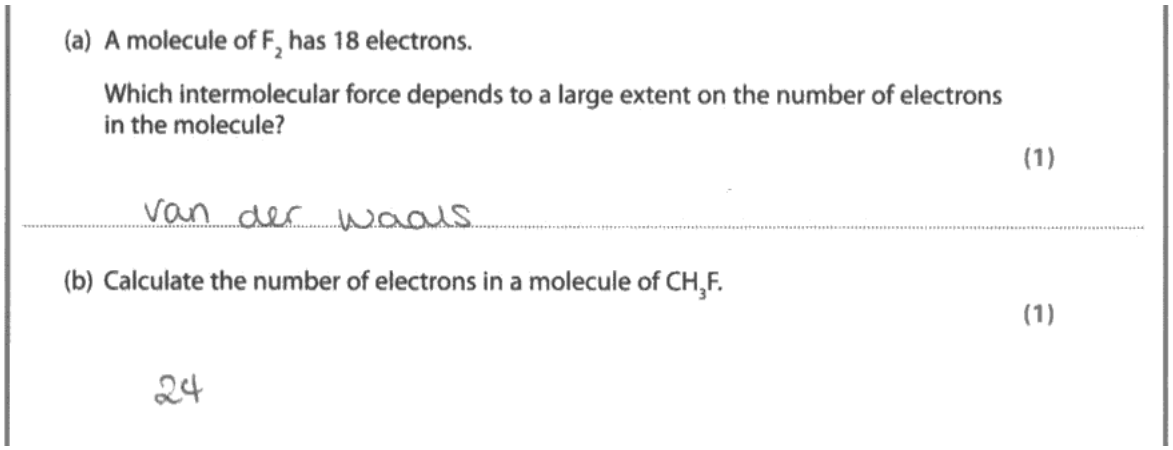
Part (i) is fine for 2 marks. Part (ii) has an additional hydrogen on the carbonyl carbon which meant that the mark was not awarded.

Part (iii) does not refer to the bond of the OH group and in fact the last line of the answer could be interpreted as a hydroxide ion. Hence this did not score.

Question 23 (a) (b)

The vast majority of candidates correctly identified the intermolecular forces in part (a). Only a minority erroneously gave dipole-dipole forces.

It was surprising that even many of the higher ability candidates got part (b) wrong, with 34 being a common answer from the use of mass numbers. Candidates should know that the number of electrons is equal to the number of protons in a neutral atom.



(a) A molecule of F_2 has 18 electrons.

Which intermolecular force depends to a large extent on the number of electrons in the molecule?

(1)

van der waals

(b) Calculate the number of electrons in a molecule of CH_3F.

(1)

24

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Examiner Comments

A number of different alternatives were allowed in part (a), in addition to the expected answer of 'London forces'. This example shows one answer which was given the mark and note that the spelling of the name is correct which was not always the case. Phonetic spellings are allowed where there is no confusion between other chemical concepts or compounds.

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Examiner Tip

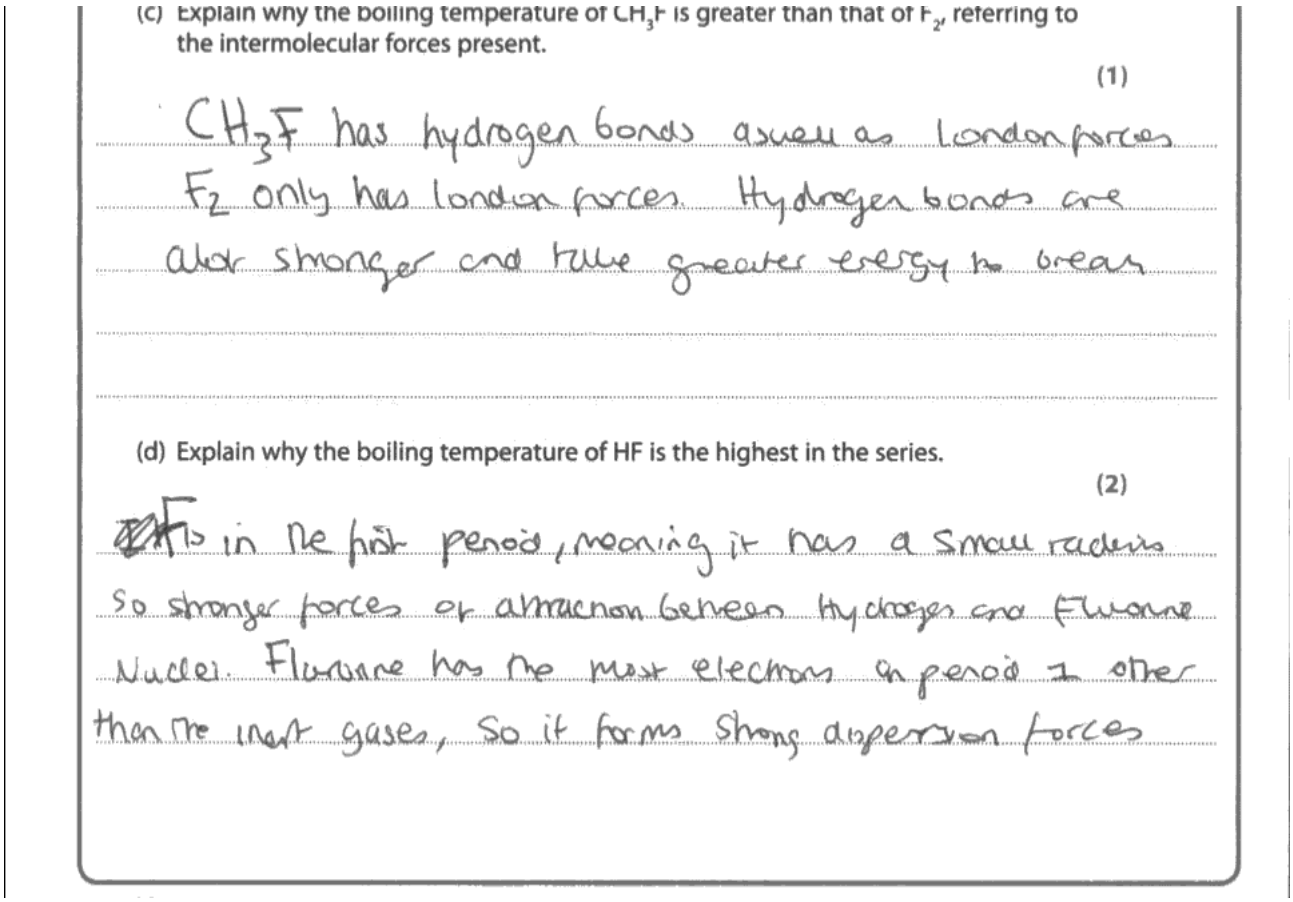
Abbreviations such as IDID and VDW for the intermolecular forces in part (a) are not allowed unless first explained,

Question 23 (c) (d) (e)

In part (c) it was common to see one of two incorrect statements either that CH_3F had more electrons or that it had hydrogen bonding. In addition some candidates correctly identified that the bonds in CH_3F were polar but failed to then go on and state that the intermolecular forces were permanent dipole-dipole forces.

The lack of clarity in part (d) frequently severely hindered candidates. The vast majority referred to hydrogen bonds but it was often not clear whether these were within the molecule or between the molecules. Certainly candidates need to have it stressed that if they want to be sure to gain the marks for questions on intermolecular forces then they must be careful how they express themselves. Explicit reference to the forces between the molecules is required. A significant number of responses salvaged their answers by reference to hydrogen bonding being the strongest intermolecular forces which illustrates what was required for the second mark, namely some comparison to other weak intermolecular forces. Generally only the better candidates gave such a comparison.

Part (e) sadly continued the theme of imprecise language. A very significant number of candidates answered in terms of 'Cl not being electronegative enough to have hydrogen bonding'. This was not credited because in the stem of the question one of the molecules quoted was chlorine itself and the trend in boiling temperatures differs with HCl not Cl_2. Candidates needed to express clearly that it was hydrogen chloride that didn't have hydrogen bonding and not just chlorine.



(c) Explain why the boiling temperature of CH_3F is greater than that of F_2, referring to the intermolecular forces present.

(1)

CH_3F has hydrogen bonds as well as London forces F_2 only has london forces. Hydrogen bonds are also stronger and take greater energy to break

(d) Explain why the boiling temperature of HF is the highest in the series.

(2)

F is in the first period, meaning it has a small radius So stronger forces of attraction between hydrogen and Fluorine Nuclei. Fluorine has the most electrons in period 1 other than the inert gases, So it forms strong dispersion forces

(e) Explain why the values of the boiling temperatures for Cl_2, CH_3Cl and HCl do not follow the same trend as F_2, CH_3F and HF.

(1)

There are Hydrogen bonds between Hydrogen bonds from between fluorine and Hydrogen but not Chlorine and Hydrogen.

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Examiner Comments

This response in (c) illustrates a fairly common misconception. Fluoromethane does not have hydrogen bonds because the fluorine is not bonded to a hydrogen. Hence this does not score.

In (d) this candidate is attempting an explanation which is what the question was requiring. However in this part there is no reference to hydrogen bonding between the molecules. The only reference is to dispersion forces in comparison to other elements in the period; it should of course be period 2 and not period 1! The series actually referred to is that of the compounds of fluorine given at the beginning of the question.

The answer to part (e) does refer to hydrogen bonds but it really is not clear whether these are between a hydrogen of one molecule and a fluorine of another molecule, or between the hydrogen and fluorine within a molecule. The comparison then with hydrogen and chlorine similarly is not clear and so did not score. As highlighted above candidates must be very clear in their expressions exactly what is being referred to.

Question 24 (a) (i)-(v)

Candidates answered parts (i) - (iv) very well, generally gaining all the marks. There were rare times when a zero was lost when moving between parts of the question.

However, in part (v) the performance of candidates was much more varied and allowed those of the higher ability range to demonstrate their ability. The question in part (v) asked for the percentage of tin in the rock and so the relative atomic mass of tin, 118.7, was required. A significant number used the value for tin(IV) oxide, namely 150.7, which illustrates the need for candidates to make absolutely sure that they have read the question carefully and have given the answer required. Provided that the percentage was correctly calculated for tin(IV) oxide these candidates did score one mark out of two since they had only made one error.

(a) Thiosulfate ions react with iodine as shown below.

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

(i) Calculate the number of moles of sodium thiosulfate which were used in **Step 4**.

$\text{moles} = \frac{11.6 \times 0.1}{1000} = 1.16 \times 10^{-3}$ (1)

(ii) Calculate the number of moles of iodine which reacted with this amount of sodium thiosulfate.

$\frac{1.16 \times 10^{-3}}{2} = 5.8 \times 10^{-4}$ (1)

(iii) Calculate the number of moles of iodine added to the solution of Sn^{2+} ions in **Step 3**.

$\text{moles} = \frac{50 \times 0.25}{1000} = 0.0125$ (1)

(iv) Use your results from (ii) and (iii) to calculate the number of moles of iodine which reacted with the Sn^{2+} ions from the rock.

(1)

$0.0125 + 5.4 \times 10^{-4}$

$= 0.01304$

118·7

(v) Hence calculate the percentage by mass of tin in the rock. (2)

moles · mass = 0.01304 × 118·7
= 1·548 g

$\frac{1.548}{10.25} \times 100 = 15.1\ \%$

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Examiner Comments

The first three parts of this question are carried out correctly. There are no units given by the candidate but they are referred to in the question so that is fine. If units are given the obviously they have to be correct or they will be penalised once.

Part (iv) incorrectly has an addition rather than a subtraction and so does not score.

However the principle of transferred error is applied here in part (v) and both marks were awarded for a correct calculation and result from the value used.

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Examiner Tip

Even if a candidate is unsure about part of a calculation it always makes sense to have an attempt and then to continue the calculation because transferred error can result in marks being awarded.

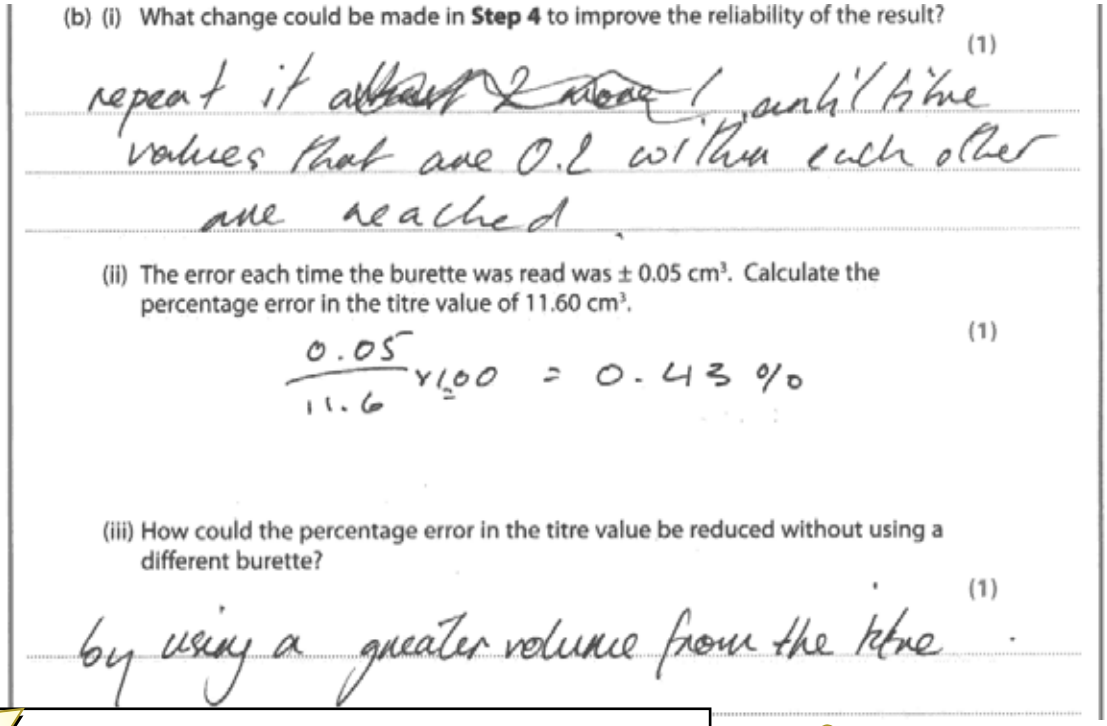
Question 24 (b) (i)-(iii)

This was a very discriminating question and only the more able were able to score any points at all and even those of higher ability were spread out in terms of the marks awarded.

Part (a)(i) - The vast majority of candidates realised that for reliability to be improved an experiment needs to be repeated. However this alone did not gain any credit because in the context of the question as set there was only one sample of the rock to analyse. What was required was for the candidate to express, in some way, that the sample would be divided or split into several portions, and then each of these would be analysed so that repeats are then created. Only a minority of higher ability candidates appreciated the situation and gave this answer.

Part (a)(ii) - This was the mark that was the most commonly achieved but even then relatively rarely. Candidates need to remember that when carrying out a titration there are two readings of the burette, the initial and the final. Hence the burette error needs to be doubled and this results in an answer of 0.86%. The answer of 0.43% for a single burette reading was frequently seen but gained no credit.

Part (a)(iii) - Similarly to above many candidates appreciated that there was a need to increase the titre to reduce the percentage error but the question asked for HOW this could be achieved. The most common correct answer was to decrease the concentration of the sodium thiosulfate solution and the more able did at times state this. Alternatively a larger volume of excess iodine could have been given as a suitable answer.



(b) (i) What change could be made in **Step 4** to improve the reliability of the result?

(1)

repeat it ~~about 2 more~~ until 3 titre values that are 0.2 within each other are reached

(ii) The error each time the burette was read was ± 0.05 cm³. Calculate the percentage error in the titre value of 11.60 cm³.

(1)

$\frac{0.05}{11.6} \times 100 = 0.43\ \%$

(iii) How could the percentage error in the titre value be reduced without using a different burette?

(1)

by using a greater volume from the titre

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Examiner Comments

In all three parts of this question the candidate has shown some understanding but not enough for any marks at all.

In part (i) there is reference to the need for repeats but no statement about dividing the sample into separate portions that would be required for repeats.

In part (ii) the correct type of calculation has been done but of course in a titre there are two measurements, the initial and final. Hence the error needed to be doubled.

The correct understanding is shown in part (iii) in that the titre needs to be increased but without an explanation of how this is achieved there is no credit.

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Examiner Tip

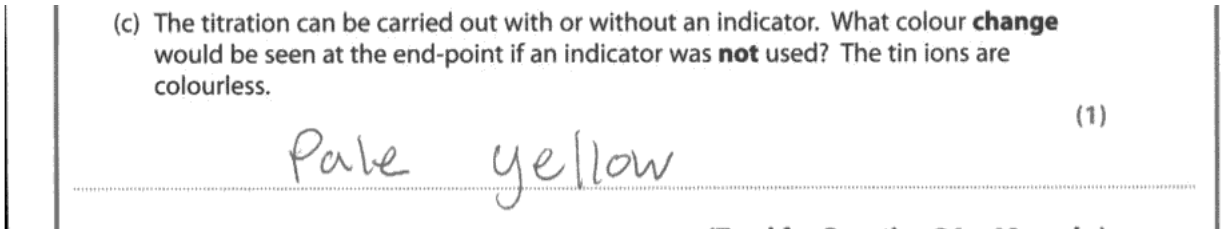
Percentage error calculations are commonly seen in coursework tasks but they can be seen in examination papers too. Hence all types of practice from coursework and practical activities do need to be revised for theory papers.

Question 24 (c)

This was another question which discriminated well. The question had two words highlighted in bold in order to help candidates, however it appeared as if these were not always noted. For example the second emboldened word was 'not' referring to the point about an indicator not being used. There were still some candidates who gave colours associated with common indicators such as starch and phenolphthalein.

The first emboldened word was the main one that differentiated between ability. The question specifically required the colour 'change' that would be observed without an indicator and so the answer "pale yellow to colourless" was looked for. Many candidates only gave one of these and so did not score.

In addition, a significant number wrote "brown to colourless" but this was not given credit since the question was asking for the colour change at the 'end-point' and this answer refers to that seen for the whole experiment.


(c) The titration can be carried out with or without an indicator. What colour **change** would be seen at the end-point if an indicator was **not** used? The tin ions are colourless.

(1)

Pale yellow

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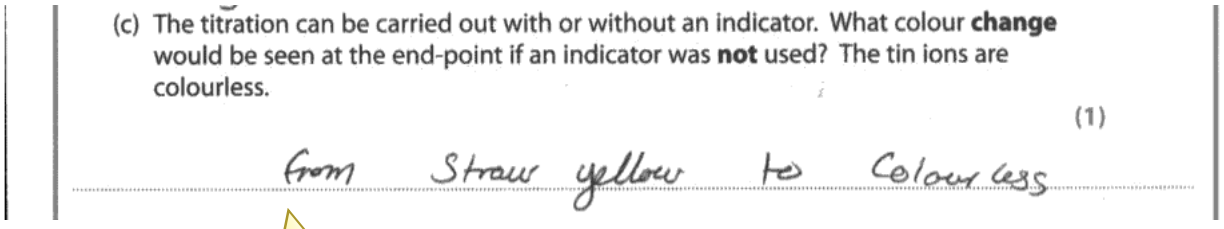
Examiner Comments

This is an example of the initial colour being correct but because there is no final colour given for the 'change' as in the question, this response did not score.


(c) The titration can be carried out with or without an indicator. What colour **change** would be seen at the end-point if an indicator was **not** used? The tin ions are colourless.

(1)

From Straw yellow to Colourless

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Examiner Comments

It was quite common to see the initial colour as "straw" yellow and this was perfectly acceptable to accompany a change to colourless.

Question 25 (a) (i)

There were a number of different ways that the calculation that was required in this question could be done and all were seen. This meant that it was vital for candidates to clearly lay-out their working out and to make sure that the units were given. If the units were not given then the comparison was meaningless.

(i) Show by calculation that a solution containing 2.2 g dm^{-3} of bromine is richer in bromine than one containing 60 ppm.

[Assume that the mass of 1 dm^3 of the bromine solution is 1000 g]

(1)

$\frac{60 \times 1000}{1000000} = 0.06$ g

$2.2\ g\,dm^{-3} > 0.06\ g\,dm^{-3}$

∴ Solution containing 2.2g dm^{-3} of bromine is richer in bromine.

ResultsPlus
Examiner Comments

A high quality answer which clearly lays out the two values with the same units and makes it clear which is the larger.

(i) Show by calculation that a solution containing 2.2 g dm^{-3} of bromine is richer in bromine than one containing 60 ppm.

[Assume that the mass of 1 dm^3 of the bromine solution is 1000 g]

(1)

60 Bromines per million

$2.2 \times 1000 = 2200$ parts per million

ResultsPlus
Examiner Comments

This is another of the ways that the numbers could be compared, i.e. both having the 'ppm' units. This was one of the more common ways that the mark was achieved as it was not necessary from the way that the question was phrased for the candidate to 'spell out' which was the larger. However candidates should always be advised to be clear in their answers because in this way the question was not the norm.

(i) Show by calculation that a solution containing 2.2 g dm^{-3} of bromine is richer in bromine than one containing 60 ppm.

[Assume that the mass of 1 dm^3 of the bromine solution is 1000 g]

(1)

2.2g dm^{-3} = 2200g

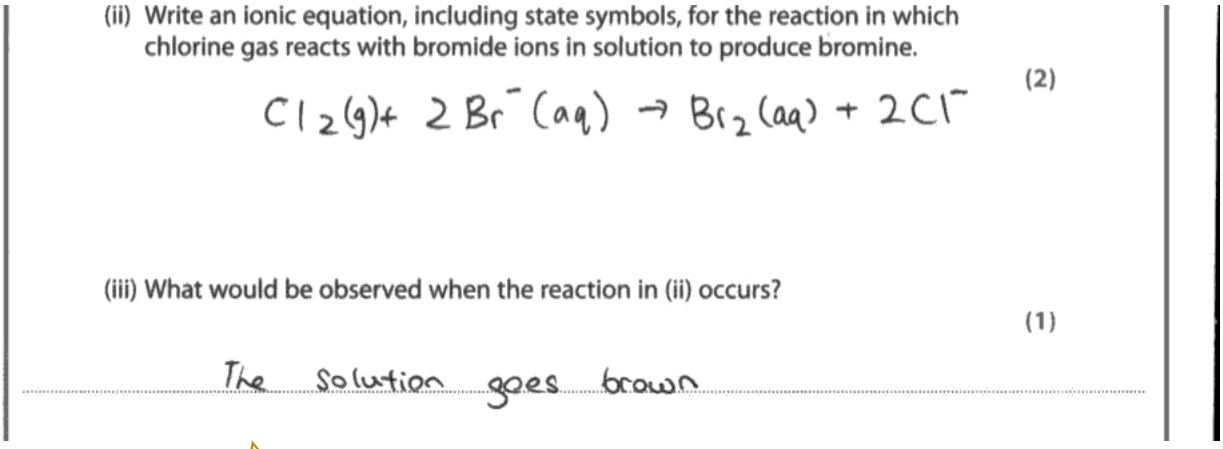
60
1000 000

ResultsPlus
Examiner Comments

How can 2.2 g dm^{-3} be equal to 2200g? Surely if this candidate had re-read their answer they would have realised that it doesn't make sense and made some changes. However this is how the response was given and obviously it gains no marks.

Question 25 (a) (ii)-(iii)

The vast majority of candidates scored one mark for an ionic equation which included all the correct species. The second mark required balancing, mostly correctly done with the 2's occasionally missing, and state symbols which is where the problem commonly lay. In part (iii) the observation of a brown/orange vapour of bromine was credited because this is something that can actually be seen given a suitably high concentration of solution; however the predominant species for bromine is obviously the aqueous form. Hence the state symbol required for the bromine was aqueous and this was the predominant response except for the more able candidate. Thus this question did discriminate well and allowed only the better candidates to gain both marks.



(ii) Write an ionic equation, including state symbols, for the reaction in which chlorine gas reacts with bromide ions in solution to produce bromine.

(2)

$Cl_2(g) + 2Br^-(aq) \rightarrow Br_2(aq) + 2Cl^-$

(iii) What would be observed when the reaction in (ii) occurs?

(1)

The solution goes brown

ResultsPlus
Examiner Comments

Note that the chloride ion on the right hand side is missing a state symbol. This results in the second mark not being awarded for part (ii).

Part (iii) is an example where a single colour was given instead of a colour change as asked.

ResultsPlus
Examiner Tip

Always, always double and triple-check work for such 'minor errors' as missing state symbols and the like.

Question 25 (a) (iv)-(v)

Part (a)(iv) was a 'stretch and challenge' question and proved to be understood only by the very best candidates. There was a lot of incorrect chemistry suggested by candidates and only the more able appreciated that an acid is a proton donor and so the addition of an acid will increase the concentration of H^+ ions. Many thought that it was significant that it was hydrochloric acid and had the chloride ions reacting in all manner of different ways, presumably as a follow-on from their answers to part (a)(ii). This question was actually trying to get candidates to appreciate the effect of a change on a system in equilibrium and thus the second mark was for the movement of the position of equilibrium to the left to counteract the afore-mentioned increase in H^+ ions. Only the higher-ability candidates showed that they understood this. It would be good for candidates to look at a number of this type of equilibrium questions to increase their understanding.

The responses to part (a)(v) were much better, presumably because the question had told the candidates that there was an effect on the equilibrium position. The vast majority correctly gave the shift to the right, i.e. towards the endothermic hydrolysis of bromine so that the additional heat energy could be absorbed.

(iv) Explain why the addition of an acid, such as hydrochloric acid, prevents hydrolysis of bromine.

(2)

The halide in hydrochloric acid is not a strong enough ~~reducing~~ oxidising agent to cause the hydrolysis of bromine. The halide should be more powerful than the halogen.

(v) Assuming the hydrolysis of bromine is endothermic, explain how an increase in temperature would affect the equilibrium position for the hydrolysis of bromine.

(2)

An increase in temperature will cause the equilibrium position to move in the endothermic direction ~~and~~ in order to oppose the increase in temperature.

ResultsPlus
Examiner Comments

Part (iv) is an example of some incorrect chemistry that was suggested for this question.

Part (v) scores one mark for the reference to movement in the endothermic direction but alas does not state clearly which direction this is.

Question 25 (a) (vi)

This was another high-scoring question with a large majority of candidates giving the textbook explanation for the effect of temperature on reaction rate in terms of an increase in the proportion of particles that have or exceed the activation energy. There were a significant minority of candidates that did not refer to the activation energy despite it being asked in the question and simply stating that the energy of the particles would increase. This did not score. Alternatively a rather worrying assertion that the activation energy was changed, normally lowered, was given but this is the effect of a catalyst and not temperature.

Candidates frequently wrote far too much and ended up writing outside of the three lines provided. It would be good to remind them that this is really not good practice. There was only one mark for this question and three lines should have been more than adequate. It seemed that many candidates starting writing before they had got their thoughts clearly in mind. This led to waffle or a re-statement of the question which was unnecessary.

(vi) Use your knowledge of activation energy to explain why an increase in temperature increases the rate of hydrolysis of bromine.

(1)

the activation energy is greater for the endothermic reaction than the exothermic reaction, so the activation energy required will be lowered and the hydrolysis will react faster

ResultsPlus
Examiner Comments

An example of the clear misconception by some candidates that the activation energy is changed either by temperature or as expressed here by whether the reaction is exothermic or endothermic.

Question 25 (a) (vii)

This was generally done well and it appears that the use of oxidation numbers is something that candidates find fairly straight-forward. The most common errors were often those of omission. For example, all 3 oxidation numbers for the bromine were given but the species with these numbers were not identified. Or the number changes and the species were given but there was no reference to oxidation or reduction which was really the point of the question as an illustration of disproportionation.

Occasionally marks were 'rescued' from annotations above the equation in that this allowed the species and the oxidation numbers to be identified. This should not really have been necessary and candidates should be reminded to always make it clear what they are referring to.

(vii) Use the equation for the hydrolysis of bromine to show that it is a disproportionation reaction.

$$Br_2(aq) + H_2O(l) \rightleftharpoons 2H^+(aq) + Br^-(aq) + BrO^-(aq)$$

(2)

Bromine begins at an oxidation state of 0 in the reactants. However in the products it has oxidation numbers of 1- (Br^-) and 1+ (BrO^-) therefore it has been disproportionated.

ResultsPlus
Examiner Comments

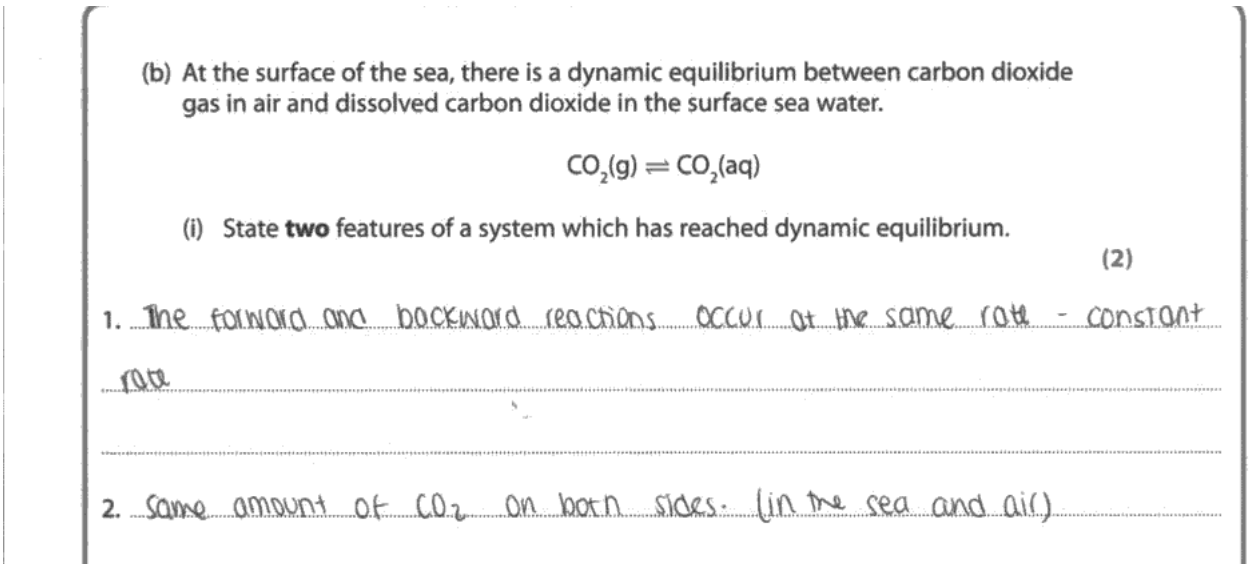
This candidate has correctly identified the bromine species with the oxidation numbers for one mark but has not then gone on to explain that this is disproportionation because bromine has been both oxidised and reduced.

Question 25 (b) (i)

By far the most common mark awarded was for the same reaction rates for both the forward and backward reactions. There were a sizeable minority that omitted the word rates and simply stated that the reactions were the same which of course is incorrect.

There appears to be some misunderstanding by a significant minority of candidates of one of the features of a dynamic equilibrium, namely that of the constant concentrations of products and reactants. It was not uncommon to see a response which stated that the reactants and products have the same concentration. This is incorrect. However the replacement of the word 'have' with 'remain' now becomes correct. This somewhat subtle change in the expression used was not always appreciated by candidates.

In addition awareness of the situation being asked was lost on some candidates who simply stated the textbook definitions of dynamic equilibrium features. This was evident by those candidates who stated that one feature was that the system was 'closed'. The context of this question is "the surface of the sea" and so this is not a closed system. Clearly appreciation for the context of the question is needed by candidates.



(b) At the surface of the sea, there is a dynamic equilibrium between carbon dioxide gas in air and dissolved carbon dioxide in the surface sea water.

$$CO_2(g) \rightleftharpoons CO_2(aq)$$

(i) State **two** features of a system which has reached dynamic equilibrium.

(2)

1. The forward and backward reactions occur at the same rate - constant rate

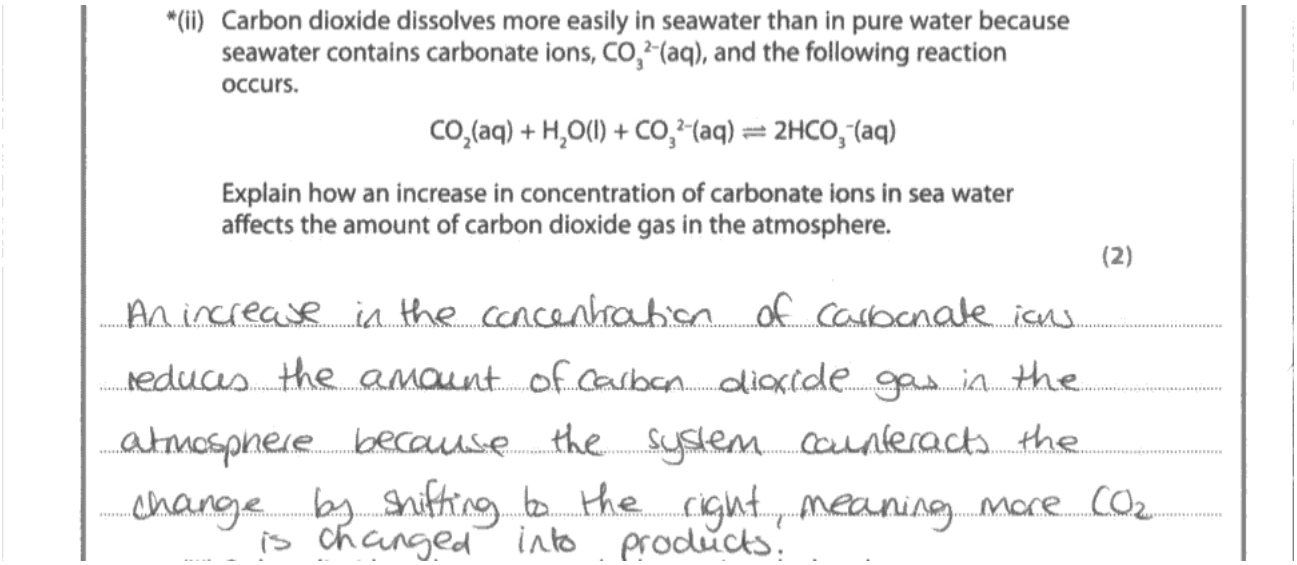
2. same amount of CO_2 on both sides. (in the sea and air)

ResultsPlus
Examiner Comments

This is an example of how the second feature was stated incorrectly. The concentrations are not 'the same' but they do 'remain the same/are unchanged'.

Question 25 (b) (ii)

This proved to be a challenging question for the candidates and lack of precision in expression again contributed towards many not scoring both points. In this question there were in effect two types of carbon dioxide, the aqueous form and the gaseous form and the distinction was not always clear in the answers given. If the candidate referred to the equilibrium position shifting to the right hand side which then resulted in a decrease in the amount of carbon dioxide in the atmosphere, gaseous, then this was awarded one mark. What was additionally needed was a comment as to how these two were actually linked. The addition of carbonate ions does result in a shift in the equilibrium position to the right and this results in a decrease in the carbon dioxide dissolved in the water, aqueous. This then will affect the earlier equilibrium stated at the beginning of question (b) such that the position of equilibrium will also shift to the right and result in a decrease in gaseous carbon dioxide. It was this second point that was rarely awarded because candidates often did not clearly state that the carbon dioxide that they were referring to was the dissolved or aqueous type.



*(ii) Carbon dioxide dissolves more easily in seawater than in pure water because seawater contains carbonate ions, $CO_3^{2-}(aq)$, and the following reaction occurs.

$$CO_2(aq) + H_2O(l) + CO_3^{2-}(aq) \rightleftharpoons 2HCO_3^-(aq)$$

Explain how an increase in concentration of carbonate ions in sea water affects the amount of carbon dioxide gas in the atmosphere.

(2)

An increase in the concentration of carbonate ions reduces the amount of carbon dioxide gas in the atmosphere because the system counteracts the change by shifting to the right, meaning more CO_2 is changed into products.

ResultsPlus
Examiner Comments

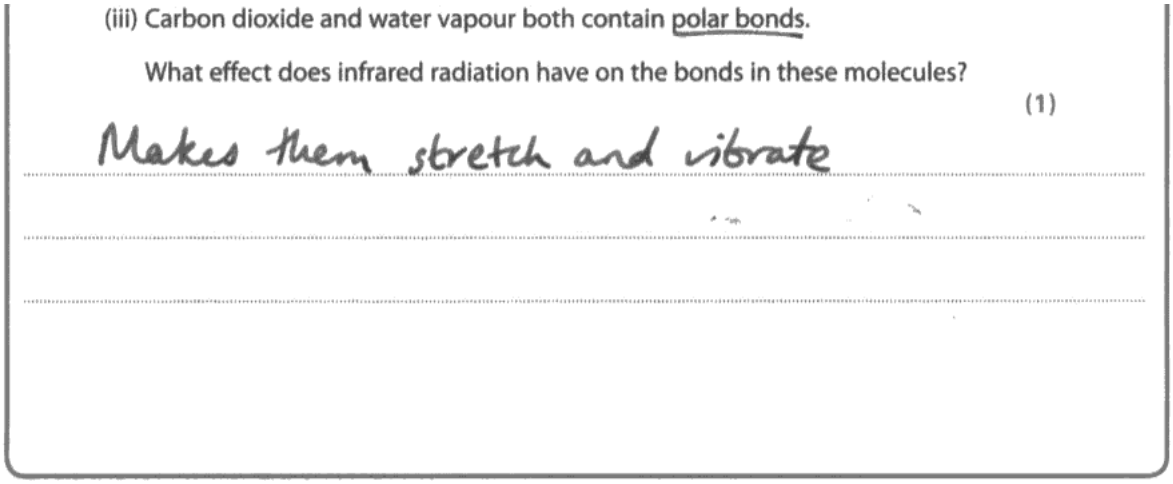
This candidate gains the mark for the decrease in atmospheric carbon dioxide due to the shift to the right of the equilibrium system. However there is no second mark because there is no reference to the reason why this happens, namely the dissolved or aqueous carbon dioxide.

ResultsPlus
Examiner Tip

It is common for a later question in a multi-part question to require information that is needed at the beginning of the question. Hence opening information should be carefully noted and kept in mind for subsequent questions.

Question 25 (b) (iii)

The majority of candidates clearly understood the point of this question and easily gained the mark. However there was a significant minority that incorrectly either referred to the molecule vibrating instead of the bond, as asked in the question, or that the bonds would be broken by the IR radiation.


(iii) Carbon dioxide and water vapour both contain polar bonds.

What effect does infrared radiation have on the bonds in these molecules?

(1)

Makes them stretch and vibrate

ResultsPlus
Examiner Comments

Since the bonds are the subject of the question this is sufficient to score the mark for this question.

Question 25 (b) (iv)

One important point that was evident from a significant number of candidates answers was that there is considerable confusion over where the IR radiation comes from which is absorbed by such gases as water vapour and carbon dioxide. While the radiation originates from the sun it is incorrect to state that these molecules absorb IR from the sun's rays. The radiation from the sun is re-emitted from the earth's surface as IR and it is this radiation that is absorbed by these molecules. It is a somewhat subtle but significant point. This is a bit like CFCs do not break down ozone but it is the chlorine free radicals that come from the CFCs that do. This key distinction is important when answering exam questions.

*(iv) Outline the mechanism by which molecules such as carbon dioxide and water cause global warming.

(2)

Carbon dioxide and water and greenhouse gases meaning they trap heat from the Earth's surface causing the temperature to rise and global warming to occur, causing climate change.

ResultsPlus
Examiner Comments

This is an example where the candidate certainly appears to know the subject. However there is no explanation for HOW the heat is trapped. Hence only one mark was awarded. This was frequently the case with candidates' answers.

Heat was allowed as an alternative to IR.

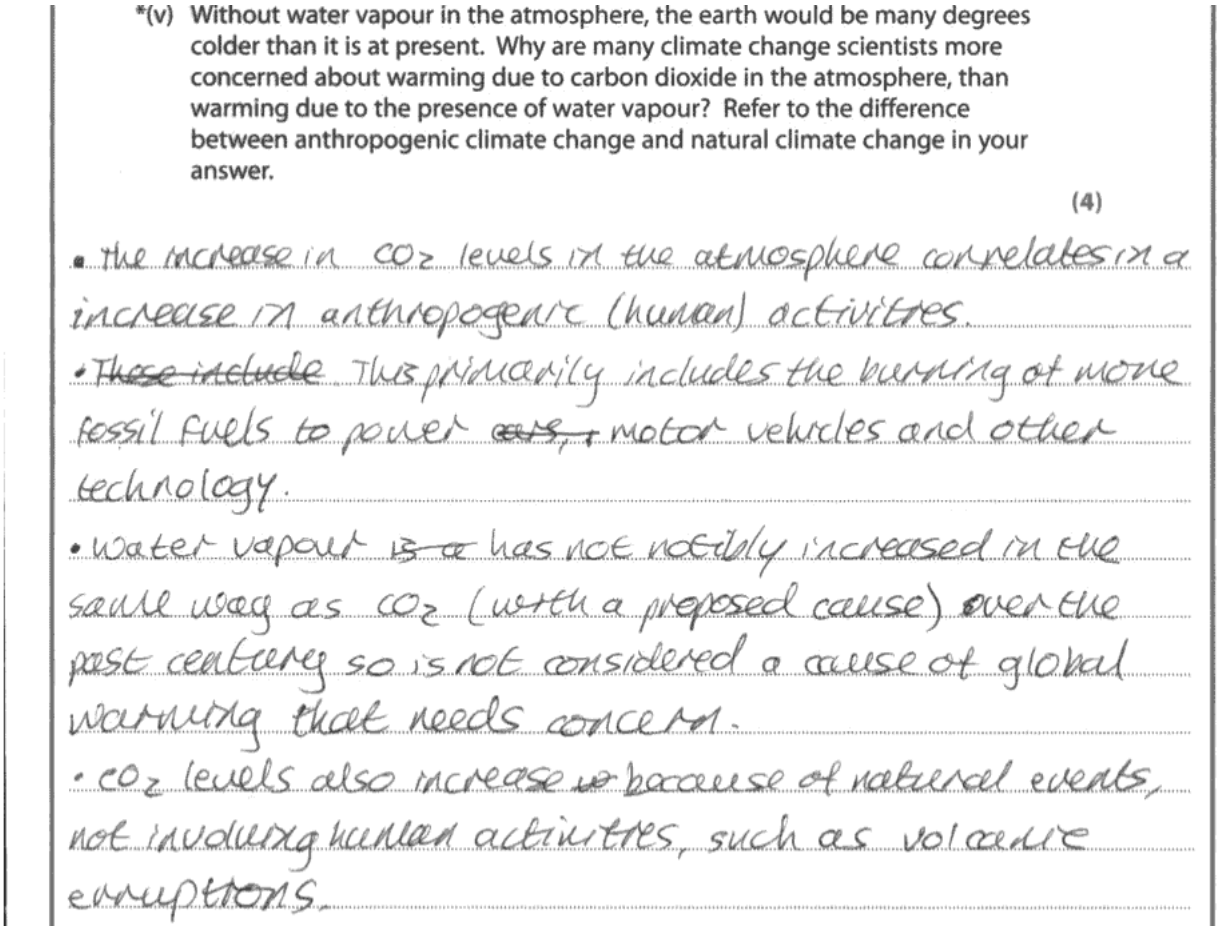
Question 25 (b) (v)

Many candidates wrote confidently on this subject and included some excellent information. At times lack of precision resulted in a lower score than otherwise might have been the case and it was not uncommon for some candidates to restate the same point several times.

The mark scheme allowed up to two marks for explaining exactly what anthropogenic and natural climate change were. The former was done much more effectively than the latter. However many considered that natural climate change is due to water vapour and that carbon dioxide is entirely a man-made problem. This is a point that centres will certainly be advised to make sure that their candidates are clear about.

Candidates could then score a maximum of three marks (up to a grand total of 4 for the question) for comments on climate change which varied from why CO_2 was increasing, with most candidates writing about a relevant cause such as the use of fossil fuels or deforestation, to the result of climate change such as rising sea levels/flooding or melting of the ice packs.

The outcome of this was that the vast majority of candidates could gain some credit for their answer and also allowed for the more able to achieve high scores.



*(v) Without water vapour in the atmosphere, the earth would be many degrees colder than it is at present. Why are many climate change scientists more concerned about warming due to carbon dioxide in the atmosphere, than warming due to the presence of water vapour? Refer to the difference between anthropogenic climate change and natural climate change in your answer.

(4)

• the increase in CO_2 levels in the atmosphere correlates in a increase in anthropogenic (human) activities.

• ~~These include~~ This primarily includes the burning of more fossil fuels to power ~~cars,~~ motor vehicles and other technology.

• water vapour ~~is a~~ has not notibly increased in the same way as CO_2 (with a proposed cause) over the past century so is not considered a cause of global warming that needs concern.

• CO_2 levels also increase because of natural events, not involving human activities, such as volcanic eruptions.

- Anthropogenic climate change is caused by humans, natural is not
- The increase in CO_2 levels is thought to cause global warming.

(Total for Question 25 = 22 marks)

ResultsPlus
Examiner Comments

This candidate has wisely broken down the question as set into different parts and is attempting to address each part in turn and doing it successfully. One mark was for a fairly constant water vapour concentration in the atmosphere and of course this can be expressed in a range of different ways. In this instance it is expressed by way of a contrast with the increase in the level of CO_2. The marks for explaining anthropogenic and natural climate change are both clearly stated here so another two marks awarded. Finally the reason for the increase in carbon dioxide is given as the burning of fossil fuels which is correct. Hence a total of 4 marks gained.

*(v) Without water vapour in the atmosphere, the earth would be many degrees colder than it is at present. Why are many climate change scientists more concerned about warming due to carbon dioxide in the atmosphere, than warming due to the presence of water vapour? Refer to the difference between anthropogenic climate change and natural climate change in your answer.

(4)

Climate change scientists think that warming of the atmosphere due to carbon dioxide is a much larger concern than warming due to water, despite water having a higher GWP than CO_2. The reason for this is that warming due to carbon dioxide is almost purely anthropogenic, whereas warming due to water vapour is almost entirely natural and very little can be done. Since the industrial revolution human activity such as driving cars and burning fossil fuels has increased and has stimulated a massive increase in Carbon Dioxide emissions. Due to Carbon Dioxide emissions being increased purely by human activity (anthropogenic) there is a lot that can be done

to bring levels back down to protect the planet. Up until the 1800s levels of CO_2 remained relatively constant but have recently shot up. Water vapour isn't a concern as levels of it have remained relatively consistent in recorded years and the balance of it has not been upset, unlike levels of CO_2. **(Total for Question 25 = 22 marks)**

ResultsPlus
Examiner Comments

Sadly not until about half way through this answer is there any comment which can be given credit. The opening comment about carbon dioxide having a greater GWP than water does not score because it needs to refer to a comparison of the individual molecules, otherwise the concentration of each has to be taken into account and water is the greater.

This answer gains marks for defining anthropogenic, reason for the carbon dioxide increase and finally for the effect of climate change, namely the melting of the ice caps.

ResultsPlus
Examiner Tip

If abbreviations are used then good practice dictates that the full expression is given first and then the abbreviation in brackets. Thereafter the abbreviation is fine. This is not the case in this answer.

Paper Summary

On the basis of their performance in this paper the candidates would be well advised to spend more time revising the following topics in order to improve their marks:

- The writing of reaction mechanisms with curly arrows, making sure the arrows go from and to the correct places and that any species removed is included in the mechanism.
- Answering questions on intermolecular forces, paying particular attention to hydrogen bonding in such a way that it is clear that the forces discussed are between the molecules and not the covalent bonds within the molecule.
- Understand that titration results can be improved through increased reliability and a reduction in percentage error but making sure that any suggestions are feasible in the context given.
- Recall reaction observations such as colour changes, evolution of gas, changes in physical state etc.
- Writing chemical equations so that they are balanced and that all the state symbols, if asked, are given correctly.
- Understand the impact of changes on a system in equilibrium.
- Understand that climate change can be anthropogenic or natural, the causes of both of these and their outcome.
- Carry out lots of molar calculations with units to ensure appropriate comparisons.

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