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Examiners' Report
June 2015

IAL Chemistry WCH02 01

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INTRODUCTION

This paper was accessible to the whole ability range and provided opportunities for candidates of all capabilities to demonstrate their knowledge and understanding. There was no evidence that candidates did not have sufficient time to complete the paper. There are a number of examination reminders given in the summary which candidates and their teachers would benefit from careful consideration.

The successful candidate was able to:

- Answer the question set by applying knowledge and understanding
- Use the correct chemical terms and principles in the appropriate context

The less successful candidate was unable to:

- Give sensible or relevant answers to questions about practical procedures or tasks
- Differentiate between the effect of infrared and ultraviolet radiation on molecules/bonds and their environmental impact

Question 21 (a)

This question presented candidates with an interesting real-life process in which an acid-base titration is used. Although the numbers may have been outside their normal experience of such titrations, good candidates had no difficulty in following the calculation through and obtaining full marks. However, a common mistake was to use the volume of KOH in part (i) when working out the number of moles of sulphuric acid. One of the nice points about this question, though, was that candidates could begin a fresh calculation in part (iv) which still allowed them access to full marks for that part and to part(v). Only a negative answer for the difference was not allowed a transferred error mark. Many candidates found part(v) the most difficult, and were only able to get some way towards the answer by multiplying their answer to a previous part by 56.1 to find a mass of KOH.

(a) (i) Calculate the number of moles of sulfuric acid that react with 25.00 cm^3 of the potassium hydroxide solution **R**.

(1)

$\frac{4.50}{1000} \times 0.0500 = 2.25 \times 10^{-4}$

(ii) From your answer to (a)(i), deduce the number of moles of potassium hydroxide in the 25.00 cm^3 of solution **R**.

(1)

$(2.25 \times 10^{-4}) \times 2 = 4.5 \times 10^{-4}$

(iii) Calculate the concentration, in mol dm^{-3}, of potassium hydroxide in the solution **R**.

(1)

moles = conc x vol

$$\text{conc} = \frac{\text{moles}}{\text{vol}} = \frac{4.5 \times 10^{-4}}{25/1000} = 0.018 \text{ mol dm}^{-3}$$

(iv) Calculate the **difference** between the initial concentration of the potassium hydroxide used to soak the animal skin and the concentration of solution **R**, which you have calculated in (a)(iii).

Relative Atomic Masses: K = 39.1; O = 16; H = 1

(3)

$$\text{moles} = \frac{\text{mass}}{Mr} = \frac{226.8}{56.1} = 4.042$$

$$\text{conc} = \frac{\text{moles}}{\text{vol}} = \frac{4.04}{45/1000} = 89.7 \text{ mol dm}^{-3}$$

$$89.7 - 0.018 = 89.682 \text{ mol dm}^{-3}$$

Initial KOH Concentration 90

KOH concentration in solution **R** 0.018

Difference 89.682

(v) Calculate the total mass of potassium hydroxide used up in the soaking process. Give your answer to **three** significant figures.

(2)

$89.7 \times 45/1000 = 4.0365$ mol

$4.0365 \times 56.1 = 226.4$ g

~~226.8 - 226.4 = 0.2~~

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Examiner Comments

This candidate starts well and completes parts (i) to (iii) correctly. The number '1' in the answer to (iii) is rather small but can be just about determined.

However in (iv) an error is made. Candidates are used to dividing their volumes by 1000 to convert to dm^3 but in this instance the volume is already in dm^3 and so there is no need. The result of this is that the concentration of KOH after soaking is 1000x too large. However only one mark is lost because transferred error can be applied for the appropriate subtraction to obtain the difference between the initial and final concentrations. The candidates work is a little but confusing because on the designated line the number 90 is written which is correct and acceptable to two significant figures. However it is clear from the working that this value is not used to obtain the difference, so one has to wonder why it was written. For part (iv) two marks our of three were awarded.

In part (v) only one mark is awarded because although the question requesting the mass to three (emboldened) significant figures the answer is not. The candidate has already been penalised for an incorrect division by 1000 and so this would not have been penalised again. Hence two marks could have been awarded as the method is correct but the use of four significant figures means only one mark was awarded.

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Examiner Tip

Make sure that all numbers/words are clearly written so that there is no ambiguity.

Give the answer to the required number of significant figures given in the question.

Question 21 (b) (i)

Just over 54% were able to correctly give the colour change of pink to colourless at the end-point. An additional 31% knew the colours but got the change around the wrong way and so were awarded one mark out of two. Hence the vast majority of candidates were able to score on this question.

One incorrect colour seen was purple. This colour is a mixture of blue and red and so does not score.

Question 21 (b) (ii)

It was surprising that the helpful reference to 'the particular skin used' in the question was frequently over-looked as candidates composed their answers. However the more able candidates often did notice this detail and explained how the red-brown colour from the skin would leach out into the solution and make the end-point difficult to judge. Candidates always need to be able to relate information given at the start of a question to answering latter parts.

At times the colour was mentioned but was then not connected with the difficulty of determining the colour change.

(ii) Suggest why the particular skin used might make it difficult to accurately judge the end-point of the titration.

(1)

~~Bec~~ Because the skin was coloured as it was from a red-brown cow meaning the colour change might be different.

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Examiner Comments

This response starts well because reference is made to the colour from the animal skin. However the response ends by mentioning 'a different colour change' which could be any colour. This incorrect and so the mark is not awarded.

(ii) Suggest why the particular skin used might make it difficult to accurately judge the end-point of the titration.

(1)

This is because the skin is red-brown in colour.

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Examiner Comments

This is an example where the response given is insufficient. If mention had been made of the colour of the solution been changed by the animal skin then the response would have scored.

Question 21 (b) (iii)

This was a question answered very disappointingly. Only 10% of the more able candidates were able to gain credit for their response. It does make examiners wonder if candidates are actually doing practicals like titrations as part of their education because surely if candidates had carried out titrations themselves then they would be well aware that there is no need for any concern over the presence of naked flames. The amount of ethanol present is so small and it is added to the aqueous solution so there is no realistic hazard.

(iii) Phenolphthalein is used as a solution in ethanol which is highly flammable. A student suggested that for safety reasons there should be no naked flames present during this titration.

Is this an appropriate suggestion? Justify your answer.

(1)

Not This is not an appropriate suggestion.
There is no heating involved in titration

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Examiner Comments

It is correct to state that the suggestion is no appropriate but not because there is no heating. Even if the conical flask with the reaction mixture in was heated there would still be no appreciable concern.

Question 21 (c) (i)

The percentage error calculations were generally done well, although some candidates failed to use the correct uncertainty value with the correct volume figure of the instrument. Other candidates who lost marks did not realise that a burette is read twice during a titration while a pipette is only read once.

(c) Titration experiments use equipment with a measurement uncertainty. For a pipette, the uncertainty is ±0.06 cm^3 on the volume measured. For each burette reading, the uncertainty is ±0.05 cm^3.

(i) By calculating the percentage error for the burette titre value of 4.50 cm^3, and for the pipette volume of 25.00 cm^3, show that in this case the burette error is greater than the pipette error.

(2)

$\frac{0.05 \times 2}{4.5} \times 100 = 2.2\% \simeq 2\%$

$\frac{0.06}{25} \times 100 = 0.24\%$

Burette titre % error 2%

Pipette volume % error 0.24 %

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Examiner Comments

The correct calculations have been carried out here for both marks. The final answer for the burette titre % error would not have been awarded the mark if the working had been shown because it is only given to one significant figure.

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Examiner Tip

Never give an answer to one significant figure unless it can be clearly justified or is specifically requested.

Question 21 (c) (ii)

Only a few candidates considered how to cause a larger volume of acid to be used in the titration and thus were able to give correct suggestions in part(ii). Most candidates could not think beyond the standard handling practice methods for burettes which did not gain any credit.

(ii) Suggest **two** ways by which the percentage error for the burette titre could be reduced, without changing the apparatus.

(2)

1 By using a more dilute solution of H_2SO_4 so that more volume can be used.

2 By using more ~~amount~~ volume of KOH solution so that the volume for the H_2SO_4 solution required to neutralise it is more.

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Examiner Comments

An example of a clearly-worded response which gained both marks.

(ii) Suggest **two** ways by which the percentage error for the burette titre could be reduced, without changing the apparatus.

(2)

1 put a white paper ~~back~~ under the burette, it can make you read the volume clearly.

2 ~~the eye level is zero~~ put the burette vertical to the ground

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Examiner Comments

An example of the type of general titration practice suggestions which were not relevant here and did not score.

Question 21 (c) (iii)

This was a good discriminating question for the more able candidates and the majority of these were correctly able to refer to 'concordancy' or that the difference between the values was that specified as being acceptable in the user guide. The less able candidates tended to give a vague answer about the accuracy of the trial but without specifics.

(iii) The trial titre value was not included in the calculation of the mean.

In what circumstances could the trial value be used in the calculation of the mean?

(1)

In a case when the value of the mean of the titre shows a large deviation in the values.

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Examiner Comments

This is an example of a response which did not score. The trial titre can be used if it is concordant and not if there is a large deviation. However one wonders what a large deviation actually means.

Question 22 (a) (i)

Only 10% of candidates could correctly complete the ozone dot and cross diagram for ozone. Most found the structure and shape of ozone beyond their understanding, failing to realise that a dative bond is required. Over half of the candidates still obtained one of the marks by having correct numbers of electrons around the outside oxygen atoms, although they usually were left with an incorrect number of electrons on the central atom.

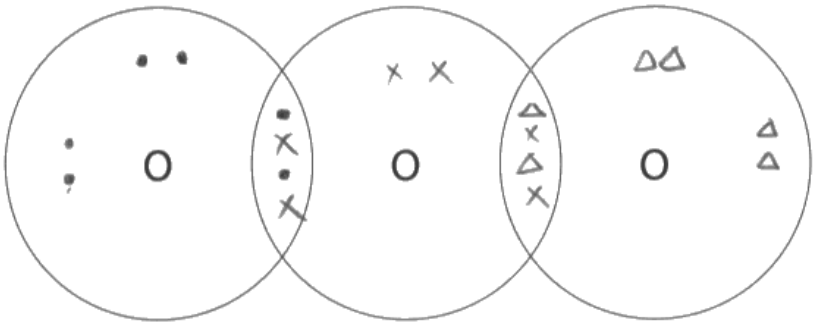
22 This is a question about environmental chemistry.

(a) Ozone, O_3, is a non-linear molecule present in the Earth's upper atmosphere. It absorbs ultraviolet radiation from the Sun and so protects living organisms from this type of radiation.

(i) Complete the dot and cross diagram for the ozone molecule. Show the outer electrons only.

Use dots (●) for the electrons of the left-hand oxygen atom, crosses (**x**) for the central oxygen atom and triangles (▲) for the right-hand oxygen atom.

(2)



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Examiner Comments

This is an example of the type of response seen which gained one mark for the two 'end' oxygen atoms having eight electrons. However it can quickly be noted that the central oxygen atom has been given 10 electrons which is obviously incorrect.

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Examiner Tip

At AS level it is important to remember the more complex options for dot and cross diagrams where either dative covalent bonds are involved (as needed here) or for the octet to be expanded (not appropriate here for an element of period 2).

22 This is a question about environmental chemistry.

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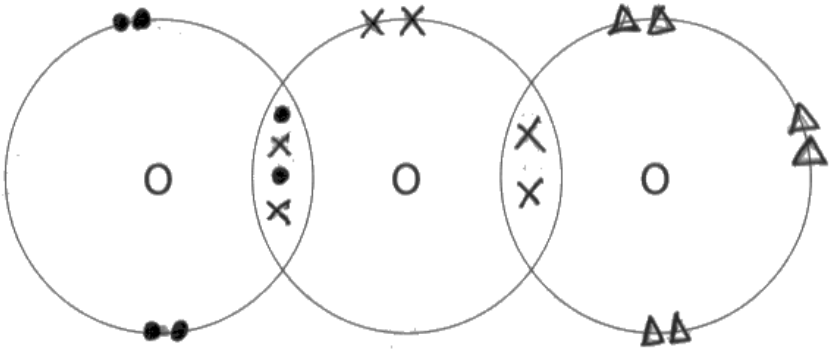
(2)



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Examiner Comments

A good example of a correct dot and cross diagram with all the relevant symbols used correctly and clearly. There is a double bond between the two oxygen atoms on the left hand side and a dative covalent bond between the two oxygen atoms on the right hand side.

Question 22 (a) (ii)

Candidates often did not understand the key role of the central atom in explaining the shape of the ozone molecule, and did not consider how many areas of electron density had to be taken into account. Many found it difficult to apply their rote learning concerning bonding and lone pair repulsions to this situation.

(ii) Explain why ozone is a non-linear molecule.

(1)

There is a lone ~~pair~~ pair of electrons on the middle oxygen.

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Examiner Comments

The ideal response described that there were three areas of electron density on the central oxygen atom, and so the molecule couldn't be linear. However a response, as seen here, that referred to the central oxygen atom having one lone pair of electrons was also awarded the mark because this is a true statement and would explain why the molecule was not linear.

Question 22 (a) (iii)

Over 80% of candidates were able to correctly state a harmful consequence of ultraviolet radiation; the vast majority of which answering 'skin cancer'.

(iii) State **one** harmful consequence to a person of increased exposure to ultraviolet radiation.

(1)

→ Cancer.

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Examiner Comments

This is an example of a response which did not score because it is not specific enough. There are many types of cancer and not all are linked to ultraviolet radiation.

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Examiner Tip

Be specific in your answers are vague responses such as harmful or dangerous are unlikely to score.

(iii) State **one** harmful consequence to a person of increased exposure to ultraviolet radiation.

(1)

~~Damage~~ Damage the Ozone layer. Make O_3 change into O_2.

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Examiner Comments

This type of response was thankfully rare but serves as a reminder to read the question carefully. It is true that ultraviolet radiation does what this candidate is stating but the question concerned the harmful consequence to 'a person'.

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Examiner Tip

RTQ^2 = Read the Question Twice

Question 22 (a) (iv)

This was a helpful discriminator between the grades as many higher ability candidates knew that uv breaks bonds (as opposed to IR which makes bonds vibrate more) but this was not so well-known by the lower ability candidates. Alternatively the correct reference to the energy/frequency/wavelength of uv was credited.

(iv) What property of ultraviolet radiation makes it more harmful than infrared radiation to living organisms? Justify your answer.

(1)

Higher frequency than infrared radiation. Therefore can penetrate the skin more easily & and reach to the cells causing multiplication and hence cancer.

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Examiner Comments

This response was awarded the mark for the reference to higher frequency of uv. The comment on the greater penetration was ignored and not given any credit.

Question 22 (a) (v)

Another question which discriminated between the grades with only the vast majority of higher ability candidates answered correctly. Presumably these candidates had either learnt this definition from their teachers or had noted from past exam papers the need to avoid reference to the plural of electrons and the need to mention a species/atom/molecule.

(v) Nitrogen oxides in aircraft emissions are involved in the depletion of the ozone layer. One of these oxides is the free radical nitrogen monoxide.

Define the term **free radical**.

(1)

It has a spare electron

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Examiner Comments

A statement that involves reference to a spare electron or a free electron does not score.

Question 22 (a) (vi)

This was a question requiring candidates to apply their knowledge and understanding as there are a number of different ways that ozone can be depleted by nitrogen oxide free radicals. The whole spectrum of marks were seen and so was an effective discriminator. Most candidates have learnt to include a 'dot' to indicate a free radical and were helped in this by the example given in the question. Common errors included an inability to balance equations for atoms, incorrect substances made or reacting and a failure to give an overall equation.

(vi) Complete the equations below for the reaction of the nitrogen monoxide with ozone.

(3)

Reaction 1 $NO^{\bullet}$ + O_3 → NO_2 + $O^{\bullet}$

Reaction 2 $O^{\bullet}$ + O_3 → O_2 + $O^{\bullet}$

Overall Reaction $2O_3$ → $3O_2$

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Examiner Comments

This is an example of a response where the candidate has failed to balance equations. For example reaction 1 has four oxygen atoms on the left hand side and only three on the right hand side.

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Examiner Tip

Always balance equations for atoms and for charge. Check and double-check.

(vi) Complete the equations below for the reaction of the nitrogen monoxide with ozone.

(3)

Reaction 1 $NO^{\bullet}$ + O_3 → $NO_2^{\bullet}$ + O_2

Reaction 2 $NO_2^{\bullet}$ + O_3 → $2O_2$ + $NO^{\bullet}$

Overall Reaction $O^{\bullet} + O_3$ → $2O_2$

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Examiner Comments

In this response the equations for Reaction 1 and 2 are correct for two marks.

However the candidates appears then to ignore their work above and to give an overall equation that has probably been learnt but is not correct for the situation shown.

Question 22 (a) (vii)

Only just over a third of candidates knew or could deduce that the role of the nitrogen monoxide in the depletion of ozone was that of a catalyst. However the vast majority of these were of higher ability and so a good grade discriminator.

Question 22 (a) (viii)

This question possibly illustrates one of dangers of trying to learn the subject from past papers. A significant number of candidates wrote about the distance from the ozone layer to vehicles such as buses and lorries which was similar to that required for a question on a past unit 2 exam paper. However in this instance the reason required was not the distance but that the nitrogen oxides would react or breakdown before they could rise to the ozone layer. Hence it is always important to apply knowledge and understanding to the situation that is presented rather than recall answers by rote.

(viii) Suggest why the release of free radical nitrogen oxides by vehicles, such as buses and lorries, does not affect the ozone layer.

(1)

Since the free radicle is released at the surface, the free radicles cannot reach the higher ~~atmf~~ section of the atmosphere

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Examiner Comments

No reason is given for why the nitrogen oxides do not reach the ozone layer and so this response does not score.

(viii) Suggest why the release of free radical nitrogen oxides by vehicles, such as buses and lorries, does not affect the ozone layer.

(1)

They will not react the ozone layer. They will react with other molecules on the way ~~and be~~ as free radicals are extremely reactive.

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Examiner Comments

An example of a good response which clearly and correctly explains the situation given in the question.

Question 22 (b) (i)

Although the reason that CO_2 is a greenhouse gas has been asked recently on previous papers, there were still many candidates who could not attribute the IR absorption to its polar C=O bonds. It was not uncommon to see CO_2 being incorrectly referred to as a polar molecule. The second mark was needed for the effect of the absorption of infrared radiation, namely the (increased) vibration of the bonds. This was the more common mark to be awarded.

(i) Carbon dioxide is a molecule in the atmosphere that absorbs infrared radiation.

Explain why this molecule absorbs infrared radiation and what effect this absorption has on the molecule.

(2)

Because they contain polar bonds, and ~~s~~ when they absorb the infrared radiation they ~~heat~~ prevent the heat from being emitted so the tempreture increase.

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Examiner Comments

The first mark is awarded for the reference to polar bonds but there is no mention of the effect of this absorption on the molecule for the second mark.

Question 22 (b) (ii)

Over 75% of candidates could correct suggest a suitable gas that does not absorb infrared radiation. Both acceptable names and formulae were seen.

(ii) Suggest a gas, of which there is a significant concentration in the atmosphere, which does **not** absorb infrared radiation.

(1)

Nitrogen, Helium

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Examiner Comments

One correct answer but sadly one incorrect one and so +1-1 =0.

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Examiner Tip

Never give multiple answers unless required as a correct response can be negated by an incorrect one.

Question 22 (b) (iii)

This was a very poorly answered question, with many misreading the question and writing about carbon dioxide instead of the CFC or about the effect of CFCs on ozone. It could be that candidates are not aware of the high absorption of IR by CFCs and if so then teachers need to remedy this. The key point of the response required was that CFCs absorb infrared radiation very effectively or strongly, with a small number of candidates using the appropriate term of high 'greenhouse factor/global warming potential'.

(iii) CFCs make a significant contribution to global warming, despite being present in only very small concentrations in the atmosphere. Suggest a reason for this.

(1)

They produce chlorine free radicals which destroys the ozone layer.

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Examiner Comments

An example of a response which states correct chemistry but does not answer the question.

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Examiner Tip

Make sure that the question is read twice to ensure that the response gives does match the question.

(iii) CFCs make a significant contribution to global warming, despite being present in only very small concentrations in the atmosphere. Suggest a reason for this.

(1)

Because it absorb infrared and prevent the heat from being emitted

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Examiner Comments

This response was not given the mark because the question referred to CFCs being in very small concentrations but still making a significant contribution to global warming and so it is the 'strong' absorption of infrared which is the crucial point. It was not enough just to state the infrared is absorbed.

Question 22 (b) (iv)

Many candidates did know and refer to the banning of CFCs. Many responses simply write about the amount of carbon dioxide being larger than CFCs but because of the very high greenhouse factor of CFCs the amount of them is not the issue and so this did not score. A higher percentage of the more able candidates were able to gain this mark.

(iv) Suggest why there is now little concern over the contribution of CFCs to global warming compared with that of carbon dioxide.

(1)

Because an alternative of CFC has been found, that is, HCFC.

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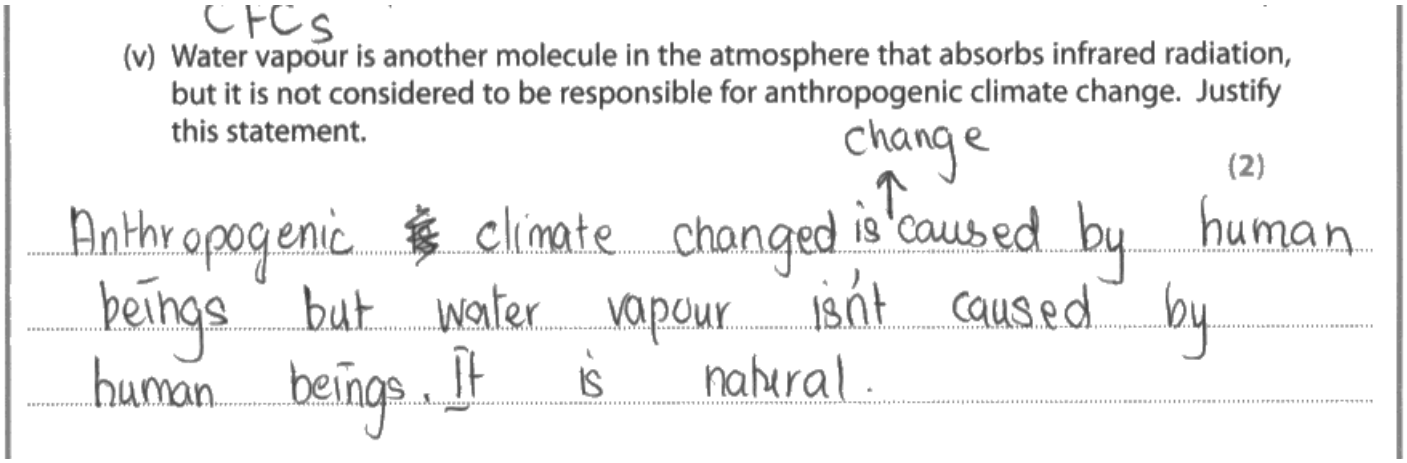
Examiner Comments

This is an example of an acceptable alternative response that was given credit. The replacement of CFCs by HCFCs does in effect mean that the level of CFCs is reduced or that their production is decreased.

Question 22 (b) (v)

It was common for candidates not to explicitly connect anthropogenic and man-made activities and to seemingly imply it instead. This made marking a challenge. Candidates generally seemed unaware of the role of water vapour in global warming and the comment that "water vapour is not produced by humans" was quite common. Some scored well, though, usually by explaining the meaning of anthropogenic, and stating that water vapour has always been present in the atmosphere from natural processes such as evaporation of sea water.



CFCs

(v) Water vapour is another molecule in the atmosphere that absorbs infrared radiation, but it is not considered to be responsible for anthropogenic climate change. Justify this statement.

change

(2)

Anthropogenic climate changed is caused by human beings but water vapour isn't caused by human beings. It is natural.

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Examiner Comments

This response is an example where anthropogenic change is correctly attributed to human activity for one mark but then a rather vague comment that water vapour is natural does not score. In addition presumably the pressure of the exam has got to the candidate so that they are not thinking straight because obviously humans do give off water vapour by breathing and by perspiration.

Question 22 (b) (vi)

It seemed that 'carbon neutral' fuels were understood but found to be more difficult to explain clearly, with the most common error being to refer to carbon instead of carbon dioxide. . The reasons why biofuels are not carbon neutral were also adequately given, although the role of fossil fuels in the production and transportation of biofuels was not usually made clear.

(vi) The term 'carbon neutrality' has become widely used with reference to biofuels. Use of biofuels is one of the measures employed in an attempt to stabilise the level of carbon dioxide in the atmosphere and hence to reduce climate change.

Explain the term 'carbon neutrality' and suggest why biofuels are unlikely to be completely carbon neutral.

(2)

Carbon neutrality is when there is no net ~~emmiss~~ emission or increase in concentration of carbon dioxide in the atmosphere. Might not be completely carbon neutral as the manufacturing of biofuels might use energy from fossil fuels which does release Co_2 and increase its net concentration in the atmosphere.

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Examiner Comments

The statement that there is 'no net emissions of CO_2' is an acceptable alternative for the definition of carbon neutrality. The following comment correctly relates use of fossil fuels in the manufacture of the fuels as a possible reason for the lack of true carbon neutrality.

Question 22 (b) (vii)

This was answered reasonably well with the majority of students picking up 1 mark. However a lot of students gave an answer relating to planting of more trees or such general energy saving as turning off lights which did not score because the focus of the question was the chemical industry and the response needed to reflect that focus.

(vii) Suggest **two** measures, other than the use of biofuels, by which the chemical industry could reduce its carbon footprint.

(2)

1 capturing and storage of carbon dioxide produced by the industry

2 Using hydrogen as a fuel as its combustion only produces water vapours.

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The first suggestion relating to carbon capture and storage is a good one and worthy of one mark. The second suggestion concerning the use of hydrogen as a fuel is not appropriate and did not score.

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Examiner Tip

Carefully review the mark scheme for a wide range of acceptable alternatives.

Question 23 (a)

It was disappointing to see so many 2-methylbutanoic acid instead of the 3-isomer and this was true of the higher ability candidates with only about one third of these candidates scoring the mark. This suggests that some reinforcement of nomenclature rules is needed by teachers.

(a) What is the systematic name for isovaleric acid?

(1)

2-methyl-~~butanoic~~ acid ~~3methyl-butanoic acid~~.

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Examiner Comments

Fortunately this candidate has had the wisdom to review their answer and appreciate the need to change their answer. Although rather messy the response is still clear and the mark can be awarded.

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Examiner Tip

Always make time to review your answers so that any necessary changes can be made.

Question 23 (b)

Although this was answered better than previous years, the determination of a molecular formula from a skeletal formula continues to prove problematic. This was more characteristic of the lower ability candidates as the majority of the higher performing candidates did well and so proved to be an effective grade discriminator.

(b) What is the molecular formula of isovaleric acid?

(1)

~~C_4H_9COOH~~ C_4H_9COOH

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Examiner Comments

This is more like a structural formula rather than a molecular formula and so does not score.

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Examiner Tip

Learn the definitions of various formulae so that the correct version can be given when asked.

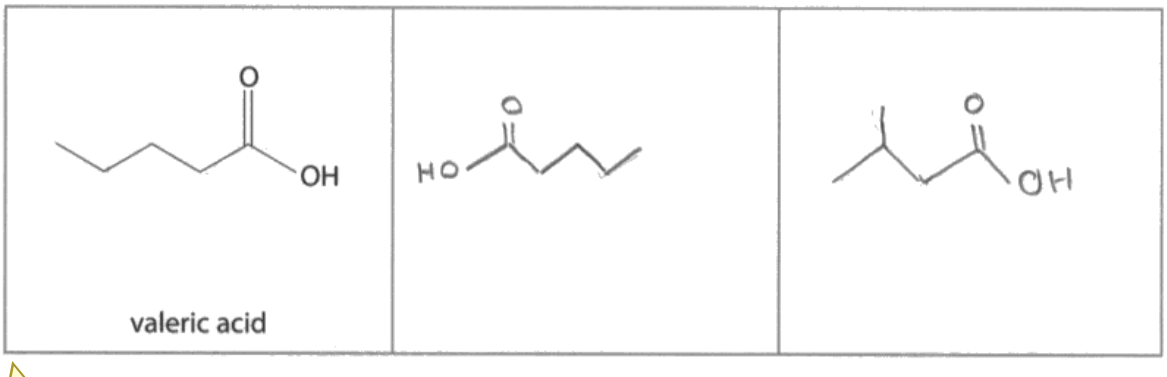
Question 23 (c)

Skeletal formula continue to prove to be challenging, especially to the weaker candidates, many of whom repeated themselves by re-drawing one of the isomers that they had already drawn. In addition many non-carboxylic acid structures were seen.

(c) Isovaleric acid has three structural isomers which are also carboxylic acids. One of these acids is drawn in the first box below.

In the empty boxes below, draw the structures, using **skeletal** formulae, of the other two carboxylic acid structural isomers of isovaleric acid.

(2)



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Examiner Comments

The first candidate skeletal formula is simply the same as the first one given but rotated 180 degrees. The second skeletal formula from the candidate is the same as isovaleric acid given in the introduction. Hence this response did not score any marks.

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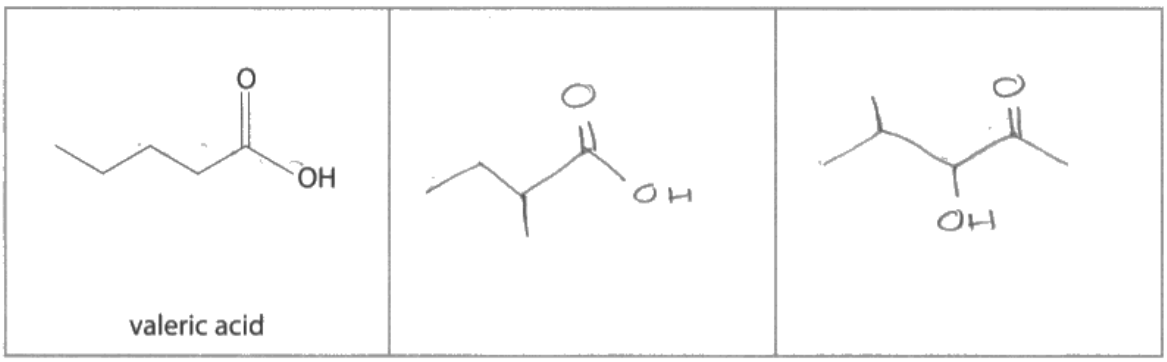
Examiner Tip

Double-check skeletal formulae are not duplicates of ones already given.

(c) Isovaleric acid has three structural isomers which are also carboxylic acids. One of these acids is drawn in the first box below.

In the empty boxes below, draw the structures, using **skeletal** formulae, of the other two carboxylic acid structural isomers of isovaleric acid.

(2)



ResultsPlus
Examiner Comments

The first skeletal formula is correct and worthy of one mark.
However the second is not a carboxylic acid and so did not score.

ResultsPlus
Examiner Tip

Double-check that the functional group required is correctly drawn with skeletal formulae.

Question 23 (d)

This was a poorly answered question with over half of the candidates not gaining any marks. The control variables of the volumes were often not considered, nor the need to mix or to stir the mixture of valeric acid and solvent. However many did recognise the MP3 mark for the relevant observations with the two solvents. The full spread of marks were seen but generally only the more able candidates scoring well.

*(d) At room temperature, valeric acid is a liquid. It is sparingly soluble in water and very soluble in ethanol.

Describe simple experiments you could carry out to show the different solubilities of valeric acid in these two solvents. No measurements are required, but you should state how you would make your experiments valid.

State the expected observations from your experiments.

(3)

Place a volume of water in a test tube. Place the same volume of ethanol in another testtube. ~~Add~~ Add the same volume of ~~valeric~~ valeric acid to both the test tubes and stir. leave for equal time at room temperature. Repeat the experiment 3 times. You will see ~~that the valeric acid has dissolved more in ethanol than in water~~ that bubbles of gas have formed. Collect the gas in a gas syringe and ~~meas~~ measure the volume of gas.

ResultsPlus
Examiner Comments

This response is rather unusual in that there is correct reference to the need for the same volumes of solvents (MP1) and for the same volume of valeric acid to be added and then stirred (MP2) but then incorrect observation comments about bubbles. Hence 2 marks awarded for this response.

*(d) At room temperature, valeric acid is a liquid. It is sparingly soluble in water and very soluble in ethanol.

Describe simple experiments you could carry out to show the different solubilities of valeric acid in these two solvents. No measurements are required, but you should state how you would make your experiments valid.

State the expected observations from your experiments.

(3)

valeric acid ~~Ethanol~~ is put into two test tubes with equal volumes. The volumes could be measured using a pipette. Then ~~equal amount~~ a certain ~~va~~ amount of known volume of ethanol is put into one and ~~the~~ the same volume of water is put into the second. The one with ethanol will be just one layer and the one with water there will be 2 layers, one is the water other is the acid.

ResultsPlus
Examiner Comments

This response is an example of one commonly seen where MP1 and MP3 were awarded but there is no mention of mixing or stirring for MP2.

ResultsPlus
Examiner Tip

Try to think about the practical procedure and what you would actually do. Then clearly write these steps down.

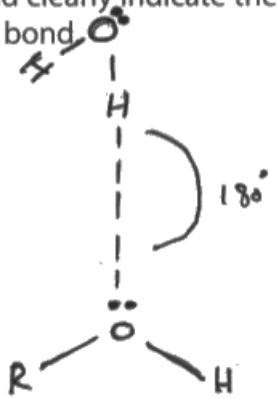
Question 23 (e)

Hydrogen-bonding drawings have often been examined but it still presents problems for many at the lower end of ability. Occasionally the hydrogen bond drawing was not at 180° but the angle was given or the position of the angle incorrect indicated between wrong atoms or no atoms at all.

(e) Isoamyl alcohol is the alcohol from which isovaleric acid can be produced directly. This alcohol forms intermolecular hydrogen bonding.

Using the simplified representation R–O–H, draw a hydrogen bond between two alcohol molecules and clearly indicate the bond angle about the hydrogen involved in the hydrogen bond.

(2)



ResultsPlus
Examiner Comments

There are two errors shown in this response. The question specifically requests a hydrogen bond between two alcohol molecules but here it is drawn between an alcohol and a water molecule. Secondly the angle is correct but the arc indicating the 180 degrees should stretch either side of the hydrogen atom concerned.

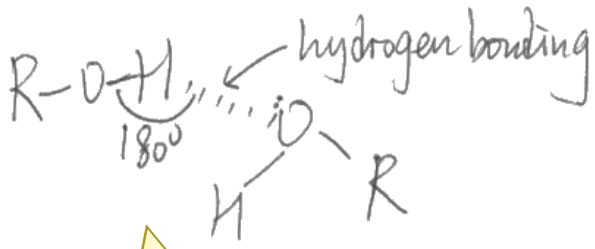
ResultsPlus
Examiner Tip

Double-check that the drawing given involves the actual molecules asked in the question.

(e) Isoamyl alcohol is the alcohol from which isovaleric acid can be produced directly. This alcohol forms intermolecular hydrogen bonding.

Using the simplified representation R–O–H, draw a hydrogen bond between two alcohol molecules and clearly indicate the bond angle about the hydrogen involved in the hydrogen bond.

(2)



ResultsPlus
Examiner Comments

The angle for the O-H...O hydrogen bond is given correctly for one mark but the drawing is clearly not 180 degrees and so this mark is not awarded.

Question 23 (f) (i)

This was a question which proved an effective grade discriminator. The weaker candidates tended to just give statements learnt by rote and either did not refer to another molecule for the induced dipole for the second mark or the temporary dipole for the first mark. The first mark was more commonly scored, however the second proved more challenging because it was rare to see another molecule referred to and only the more able candidates remembered to do this.

*(i) Describe how London forces are formed.

(2)

London forces are ~~for~~ formed by the unsymmetrical double distribution and movement of electrons in the molecules which form an instantaneous dipole in the molecules. The ~~other~~ weak attractions between these ~~do~~ instantaneous dipoles is what are called the London forces.

ResultsPlus

Examiner Comments

This response beings very well and gives a good description of how instantaneous dipoles arise. However there is no reference to this temporary dipole inducing in adjacent molecules a dipole for the London forces then to arise between them.

Question 23 (f) (ii)

A full range of marks was seen for this question. A minority thought that the straight chain isomer had a higher melting point or even that it was the same as the branched isomer. It was not uncommon to see correct reference to less surface area for contact for the branched isomer but only the more able then connected it with weaker London forces.

Although some candidates still used "bonds" when actually referring to intermolecular forces. The distinction between these terms should still be made clear and emphasised when teaching this area of chemistry.

(ii) The straight-chain structural isomer of isoamyl alcohol has a boiling temperature of 138 °C.

Suggest whether the boiling temperature for isoamyl alcohol will be higher than, lower than or the same as the straight-chain isomer. Justify your choice.

(3)

It will be lower because the london force will have len surface area to operate than the straight chain isomer so therefore len energy is required to break the bond in isoamyl alcohol'

ResultsPlus
Examiner Comments

This is an example of a response where the word 'bond' appears to be used instead of 'London force' or intermolecular force.In this particular instance this was ignored but each case had to be viewed on its own merits or otherwise.

The first mark was awarded because the isoamyl alcohol was deemed to have a lower boiling temperature. The second mark was also awarded for the reduction in surface area in the branched isoamyl alcohol. However the third mark was not awarded because there is no mention of the London forces being weaker or less due to this reduction in surface area contact between the molecules.

Question 23 (g) (i)

Some candidates who realised that Y was a secondary alcohol thought their answer as sufficient with that point. Those who read the question more carefully realised that a fuller explanation was needed to the effect that the ketone X could not be oxidised further whichever method was used and that the alcohol could ONLY be oxidized to a ketone.

(i) The oxidation of an alcohol of this type with acidified sodium dichromate(VI) could involve either reflux or distillation.

* Explain why either could be used in this case.

(1)

Alcohol Y is a ~~primary~~ secondary ~~secondary~~ alcohol and can be oxidised to form a ketone by either reflux or distillation because the same product will form.

ResultsPlus

Examiner Comments

This response just scores by the final comment stating that the 'same product will form'. This candidate has clearly reviewed their answer and fortunately reverted to the correct classification of alcohol as originally penned.

Question 23 (g) (ii)

A good discriminator for ability as generally only the more able candidates knew that a diol was formed for the second marking point. Most candidates knew that the functional group that reacts was the carbon-carbon double bond and the name or formula was awarded credit. Occasionally mention was made of just a 'double bond' and this was insufficient as candidates should know about the double bond between carbon and oxygen in carbonyls and carboxylic acids

(ii) An alternative reagent for the oxidation of an alcohol is acidified potassium manganate(VII), $KMnO_4$. However, this is likely to produce other products because **X** contains another functional group that could react with this reagent.

Name this other functional group in **X** and suggest the type of molecule formed in its reaction with acidified potassium manganate(VII), $KMnO_4$.

(2)

Functional group that reacts ~~Alkene~~ C=C

Type of molecule formed Alcohol

ResultsPlus
Examiner Comments

The first mark was awarded for the C=C but alcohol was not sufficient as a diol is formed.

(ii) An alternative reagent for the oxidation of an alcohol is acidified potassium manganate(VII), $KMnO_4$. However, this is likely to produce other products because **X** contains another functional group that could react with this reagent.

Name this other functional group in **X** and suggest the type of molecule formed in its reaction with acidified potassium manganate(VII), $KMnO_4$.

(2)

Functional group that reacts C=C double bond

Type of molecule formed alkane

ResultsPlus
Examiner Comments

Again one mark awarded for the functional group that reacts but hard to envisage how a candidate can think that an alkane is formed from the reaction with acidified potassium manganate, especially with the formula given. Presumably an area for further consolidation.

Question 23 (h)

Many candidates scored 2 marks for the IR but then seemed to stop and ignore the need for a comment on mass spectrometry. Occasionally candidates failed to quote wavenumbers with the bonds and some incorrectly selected the alkene C-H absorption. The mass spectrometry marks were rarely awarded with only the more able candidates accessing these points. This is possibly an area that candidates need to spend more time on.

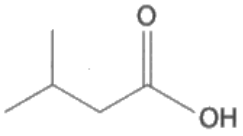
*(h) Isovaleric acid and alcohol **Y** could react together to produce a compound with a pleasant aroma, but this can be masked by even a small residue of the starting molecules.

Generally, spectroscopic methods are much more reliable than sense of smell in detecting the presence of molecules.

The infrared absorption ranges associated with some functional groups are given below.

O—H stretching in alcohols	3750 – 3200 cm^{-1}
O—H stretching in carboxylic acids	3300 – 2500 cm^{-1}
C=O stretching in aldehydes	1740 – 1720 cm^{-1}
C=O stretching in ketones	1700 – 1680 cm^{-1}
C=O stretching in carboxylic acids, alkyl	1725 – 1700 cm^{-1}
C—H stretching in alkane	2962 – 2853 cm^{-1}
C—H stretching in alkene	3095 – 3010 cm^{-1}

By quoting appropriate data, describe how both infrared spectroscopy and mass spectrometry could be used to determine the presence of **isovaleric acid**. The skeletal formula of isovaleric acid is shown below.



(4)

O-H stretching in alcohol. 3750 – 3200. ~~Carboxylic acids 3300 – 2500 cm^{-1}.~~

C=O stretching in aldehydes. 1740 – 1720 cm^{-1}.

C–H stretching in alkene 3095 – 3010 cm^{-1}.

Both Infrared spectroscopy and mass spectroscopy can be used of the huge hydroxyl band presence of OH in alcohol. C=O is also present in aldehydes and C-H is alkenes because of branching in isovaleric acid. In mass spectroscopy it will show because the bonds are broken and it will show. In Infrared spectroscopy it will also show. ~~Dif~~ because of the presence of primary alcohol is being used. and carboxylic acid is forming.

ResultsPlus
Examiner Comments

Unfortunately this response failed to score any marks. The infrared wavenumbers quoted are all incorrect; the alcohol O-H values given instead of the carboxylic acid, the aldehyde C=O values instead of the carboxylic acid and the alkene C-H values instead of the alkane. There is no reference to mass spectrometry.

ResultsPlus
Examiner Tip

Carefully select the data given and quote the values carefully as a range is provided from which only the correct ones must be used.

*(h) Isovaleric acid and alcohol **Y** could react together to produce a compound with a pleasant aroma, but this can be masked by even a small residue of the starting molecules.

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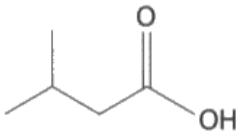

(4)

When using IR spectroscopy, we would be able to distinguish the presence of isovaleric acid by focusing on the bonds exclusive to it; like for example the C=O stretching in carboxylic acids. Therefore, a lack of transmitance in the IR spec graph between 1725 - 1700 cm^{-1} will indicate the presence of this acid.

When using mass spectrometry, we should focus on the segment exclusive to isovaleric acid, thus focusing on its mass / charge ratio. In this case, if there is a strecording in the mass of 102 (the Mr of the isovaleric acid molecule = 5×12 + 10 + 16×2 = 102) there will clearly be a presence of this molecule.

(Total for Question 23 = 21 marks)

ResultsPlus
Examiner Comments

This response was awarded 2 marks. One mark was given for the mention of the C=O 1725-1700 peak in the infrared. The second mark for the molecular ion peak at m/e=102. There is too much writing about the question rather than giving the answer.

ResultsPlus
Examiner Tip

Make sure that your response gives the number of points that matches the mark allocation.

Paper Summary

It would be beneficial if the following key points were highlighted to candidates and emphasized by their teachers in the delivery of the Chemistry course.

RTQ2 - Read the Question Twice: A significant number of candidates would have improved their total marks if they had taken the time to re-read the question and make sure that their answer was addressing the question as set. For example, if three significant figures are required for the final answer then give three significant figures.

Double-check and even triple-check answers so that any 'simple' errors can be corrected.

Equations must always balance for atoms and charge. Errors in this matter could easily and quickly be identified and then addressed from a second check.

When carrying out molar calculations candidates would benefit from highlighting or underlining the units involved. In this way a division by 1000 that would normally be required to convert to dm^3 could have been determined as unnecessary. In addition if the volumes used can be carefully attributed to the relevant compound then the correct determination of moles would be achieved.

Chemistry is a practical subject and inevitably questions relate to practical procedures so candidates need to grasp the reason for doing particular steps or why they need to. For example if determining solubility some mixing or stirring would inevitably be required in order to aid any possible dissolving.

Allow the mark allocation of the question to provide a guide as to the depth and the number of points required in the answer.

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx

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