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Examiners' Report
June 2011

GCE Chemistry 6CH02 01

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Introduction

The paper seemed to be generally accessible to candidates. All parts of all sections were attempted. There was no evidence of candidates being unable to complete the paper due to lack of time.

Question 17 (a)

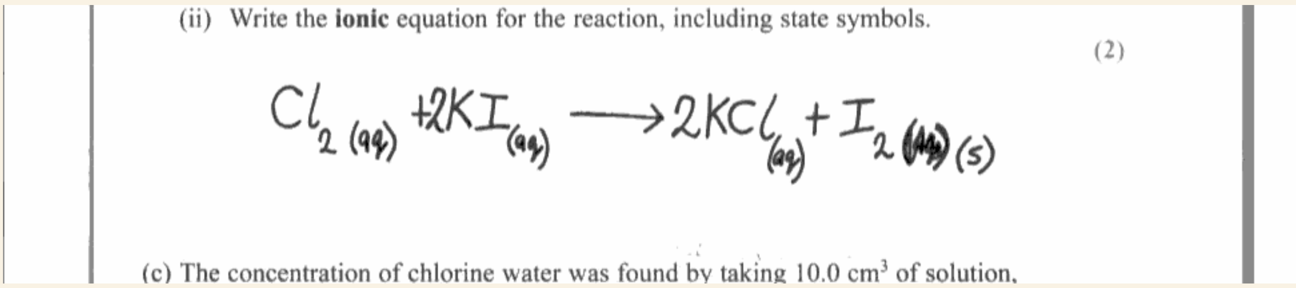
Though colourless was accepted on this occasion, a solution of chlorine in water is green. This is clearly seen if a test tube is viewed down its length and compared with a similar test tube of water. Weak candidates gave mixture of correct and wrong colours.

Question 17 (b) (i)

A mixture of colours, provided they are red/brown, was acceptable for this question, as this is the accurate description of any reasonably strong aqueous solution of iodine. Yellow, the colour of weaker aqueous solutions of iodine, was also acceptable.

Question 17 (b) (ii)

The mode mark on this question was zero. Candidates need more practice at writing ionic equations like these. A fully correct overall equation gained one mark, as did failure to eliminate the spectator potassium ions.



(ii) Write the **ionic** equation for the reaction, including state symbols.

(2)

$$Cl_{2\,(aq)} + 2KI_{(aq)} \longrightarrow 2KCl_{(aq)} + I_{2\,(s)}$$

(c) The concentration of chlorine water was found by taking 10.0 cm³ of solution,

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Examiner Comments

An acceptable overall equation which gains one mark.

Question 17 (c) (i)

About one third of candidates gave an acid-base indicator like phenolphthalein which gained no credit. About one quarter gave the colour change for starch the wrong way round or an incorrect colour combination.

(i) Name a suitable indicator for the titration. State the colour change you would expect to see at the end point.

(2)

Indicator Starch

Colour change from blue / back to colourless

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Examiner Comments

The fully correct answer.

Question 17 (c) (ii-vi)

The calculations were generally well done. Some omitted to divide by 1000 in the first part.

About one third of candidates gave an acid-base indicator like phenolphthalein which gained no credit. About one quarter gave the colour change for starch the wrong way round or an incorrect colour combination. The products of an iodine-thiosulfate titration were not well known. Some gave iodide without the stoichiometric number. Most did not know the other product was tetrathionate.

Some candidates multiplied by two, instead of dividing by two in part (iv).

Some candidates began a new calculation in (v).

A small fraction of candidates did not know how to find a concentration of a solution given a volume containing a known number of moles in (vi).

(ii) Calculate the mean titre and use this value to calculate the number of moles of sodium thiosulfate used in the titration.

Mean titre $= \frac{9.10 + 9}{2} = 9.05$ cm (1)

Mean titre = 9.05 cm^3

Moles of sodium thiosulfate

Mean

$n = \frac{c \times V}{1000}$ $n = \frac{0.01 \times 9.05}{1000}$

$n = 9.05 \times 10^{-5}$ mol

(iii) Complete the ionic equation for the reaction between iodine and thiosulfate ions. (2)

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

(iv) Calculate the number of moles of iodine which reacted with the sodium thiosulfate solution. (1)

1 : 2

$n = \frac{9.05 \times 10^{-5}}{2} = 4.525 \times 10^{-5} = 4.53 \times 10^{-5}$ mol

(v) Hence state the number of moles of chlorine present in 10.0 cm^3 of the chlorine water. (1)

1:1 reaction

$n = 4.53 \times 10^{-5}$ mol

(vi) Calculate the concentration of the chlorine water, in mol dm^{-3}.

(1)

$n = cV$

$c = \frac{n}{V}$

$c = \frac{4.53 \times 10^{-5}}{0.01\ dm^3}$ $c = 4.53 \times 10^{-3}\ mol\ dm^{-3}$

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Examiner Comments

This is a typical answer, missing only the tetrathionate ion.

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Examiner Tip

Notice how 4.525 has been correctly rounded to 4.53. Incorrect rounding like 4.52, would have been penalised, as would one significant figure.

Question 17 (d) (i)

The vast majority of candidates correctly gave 'lilac'.

(d) Potassium burns in chlorine to form potassium chloride.

(i) Give the colour of the flame when potassium burns in chlorine.

(1)

purple

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Examiner Tip

Though not strictly correct, this was acceptable.

Question 17 (d) (ii)

This equation was generally well known.

(ii) Write the equation for the reaction between potassium and chlorine. State symbols are **not** required.

(1)

$K + Cl_2 \rightarrow KCl_2$

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Examiner Comments

Some tried to balance for chlorine by changing the formula of potassium chloride, or forgetting that chlorine is a diatomic molecule.

Question 17 (e) (i)

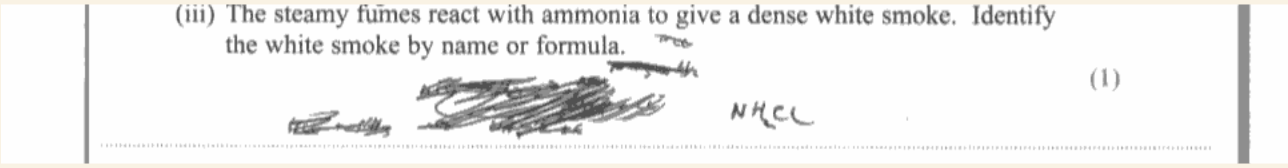
The gas given off was usually correctly identified as hydrogen chloride. Some wrongly thought the gas was hydrochloric acid. Others seemed to jump to the white smoke and identified ammonium chloride.

Question 17 (e) (ii)

The explanation of the formation of the steamy fumes was rarely correct. Many focussed on the reaction producing the gas which formed the steamy fumes. The point is that hydrogen chloride is very soluble in water, so it attracts moisture from the air to form droplets of hydrochloric acid.

Question 17 (e) (iii)

Identification of the white smoke by name was safest. There were many incorrect formulae like NH_3Cl.


(iii) The steamy fumes react with ammonia to give a dense white smoke. Identify the white smoke by name or formula. (1)

NHCL

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Examiner Comments

Some formulae had an unreadable number like this and could not receive credit.

Question 17 (f) (i)

Phosphorus(V) chloride was the most popular correct answer. Chlorine or hydrochloric acid were common wrong answers.

(f) 2-chlorobutane can be made from butan-2-ol.

(i) Name the chemical you would add to butan-2-ol in the laboratory to make 2-chlorobutane.

(1)

~~HBr in situ~~ HCl in situ

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Examiner Comments

The candidate has failed to read the question and given a formula. In reality hydrogen chloride gas does not work and even with a catalyst the yield is not high.

Question 17 (f) (ii)

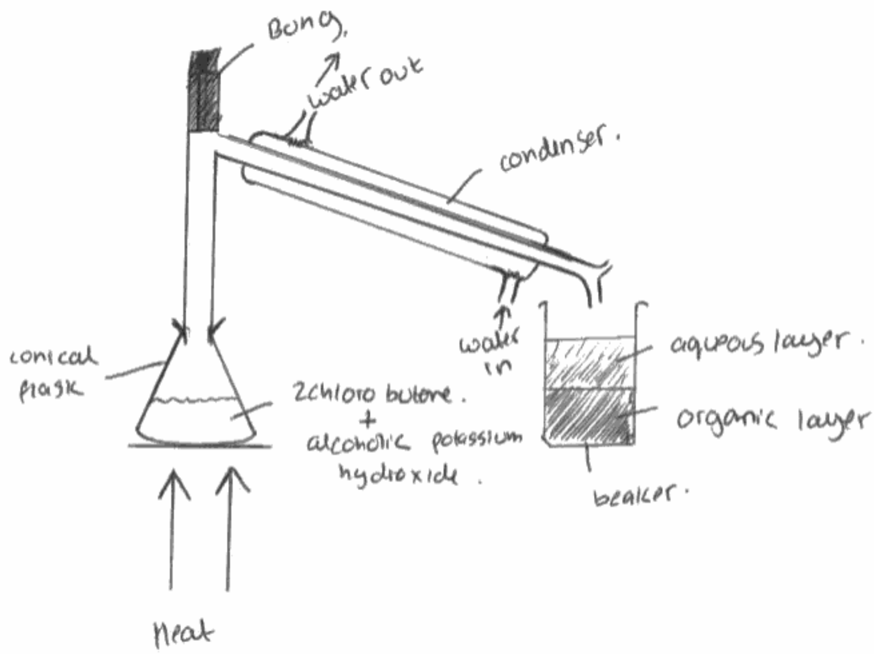
The answers to this question gave the examiners some cause for concern, as so few candidates seemed familiar with this experiment though it is clearly mentioned in the specification: '...describe the behaviour of the halogenoalkanes. This will be limited to treatment with... alcoholic potassium hydroxide'.

It was common to see distillation or reflux apparatus, with no attempt to collect the gaseous products mentioned in the question. Even these diagrams had frequent errors, like omitting a heat source, omitting the reaction mixture, sealed apparatus, or apparatus with clear air gaps at joints in the apparatus.

(ii) 2-chlorobutane reacts with alcoholic potassium hydroxide at a high temperature to form a mixture of gaseous alkenes.

Draw a fully labelled diagram of the apparatus you would use to prepare and collect this mixture.

(3)



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Examiner Comments

With a round bottom flask, this would have qualified for 2 marks. Flat botttomed flasks will crack on heating unless they are 'pyrex', which would need to be stated.

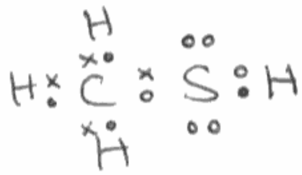
Question 18 (a) (i)

Candidates did not have many problems with drawing a dot and cross diagram for this unfamiliar molecule. The most common error was to omit the non-bonding electrons on sulphur.

18 This question is about ethanethiol, CH_3CH_2SH. Thiols are like alcohols, but the oxygen atom has been replaced by a sulfur atom. They react in a similar way to alcohols.

(a) (i) Draw a dot and cross diagram for ethanethiol, showing outer electrons only.

(2)



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Examiner Comments

In spite of the formula being given in the question, methanethiol has been drawn which was awarded one mark out of two.

Question 18 (a) (ii)

This proved a difficult question for most candidates. Many gave bond angles of 180°. The idea of non-bonding pairs of electrons repelling more than bonding pairs was often given. The principle that electron pairs adopt a position of minimum repulsion and maximum separation was rarely appreciated.

(ii) Give the value for the CSH bond angle in ethanethiol. Justify your answer.

(3)

CSH angle 104°

Justification Because there are two sets of lone pairs so the shape is bent linear. There is equal repulsion from both lone pairs.

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Examiner Comments

This answer demonstrates the confusion shown by many candidates. The bond angle is correct. The lone pairs have been mentioned but there is no real understanding of the principles involved.

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Examiner Tip

Learn that electron pairs adopt a position of minimum repulsion and maximum separation and non-bonding pairs of electrons repel more than bonding pairs.

Question 18 (b) (i)

Very few candidates were able to apply their understanding of the hydrogen bond. They did not seem to appreciate that there are two bonds, one covalent between hydrogen and oxygen, and the other between the hydrogen and a lone pair on another oxygen atom.

(b) There are hydrogen bonds between ethanol molecules but not between ethanethiol molecules.

(i) Explain why the bond angle around the hydrogen atom involved in a hydrogen bond is 180°.

(2)

The hydrogen atom is bonded ~~to~~ covalently to one atom and hydrogen-bonded to another. The electrons repel, so they are pushed as far apart as possible into a linear structure.

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Examiner Comments

Here is a good answer, recognising the two different bonds and succinctly expressing the minimum repulsion principle.

Question 18 (b) (ii)

The common insufficient answer was to state that hydrogen can only form hydrogen bonds with nitrogen, oxygen and fluorine, which is true, but misses the key point about their high electronegativity relative to sulfur.

(ii) Explain why there are no hydrogen bonds between ethanethiol molecules.

(1)

because hydrogen bond only form between oxygen nitrogen and flourine.

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Examiner Comments

The common insufficient answer.

Question 18 (c) (i)

A common error was to only answer half the question, mentioning how temporary or instantaneous dipoles arise. Another was to attribute the forces to different electronegativities between atoms, confusing them with permanent dipoles.

(c) (i) Describe the formation of London forces.

(2)

There is a temporary dipole, caused by the movement of electons in a molecule. The positive end of one molecule is attracted to the negative end of another.

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Examiner Comments

This answer does not mention the formation of induced dipoles.

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Examiner Tip

Learn the alternative name for London forces as instantaneous dipole induced dipole forces.

Question 18 (c) (ii)

Many candidates found it difficult to apply their knowledge that London forces primarily depend on the number of electrons in a molecule. As sulphur has more electrons the forces are stronger in thioethanol.

(ii) Explain why the London forces in ethanethiol are stronger than those in ethanol.

(1)

Because Sulphur is larger than Oxygen So the electrons have More Shielding etc. So are More ~~[illegible]~~ ready to form London forces.

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Examiner Comments

Here the candidate has given a common response that sulphur is bigger, which is not sufficient. They have failed to say specifically that sulphur has more electrons.

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Examiner Tip

London forces primarily depend on the number of electrons in a molecule.

Question 18 (d) (i)

Most candidates were familiar with adding sodium to an alcohol and correctly applied their knowledge. Weaker candidates recalled the reaction of sodium with water and wrote about a vigorous reaction, or heat given out or steam forming.

Question 18 (d) (ii)

The key to this equation is the formula of the organic product CH_3CH_2SNa, with the 'SNa' replacing 'ONa' in sodium ethoxide. Then the easiest way to balance the equation is to put one half in front of the other product, H_2.

(ii) Suggest a balanced equation for this reaction. State symbols are **not** required.

(1)

$Na + CH_3CH_2SH$

$\rightarrow CH_3CNaS + H_2$

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Examiner Comments

This illustrates the weakness of attempting to balancing equations by changing the formulae of the chemicals.

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Examiner Tip

Always write the formulae of the chemicals in an equation first, then balance by adding appropriate numbers before each entity.

Question 18 (e) (ii)

Many candidates confuse type and mechanism of reaction. Types of reaction in this context are substitution, elimination or addition. Mechanisms are nucleophilic, electrophilic or free radical.

Question 18 (e) (iii)

Most candidates were able to give the equivalent of potassium hydroxide with a sulphur instead and correctly gave KSH. As water also gives this reaction, H_2S was also allowed.

Question 18 (f)

(f) When ethanethiol undergoes complete combustion in air, a gas is produced which is not formed on the complete combustion of ethanol. Identify the gas and suggest why it is damaging to the environment.

(2)

Carbon dioxide is a damaging to the environment as it traps UV light from the sun warming up the earth and causing global warming.

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Examiner Comments

The candidate has not read the question. '...not formed on complete combustion of ethanol...' So gains no credit.

Question 19 (a) (i)

Answers showed a lack of precision. A free radical is an atom, molecule or ion with an unpaired electron.

(a) (i) What is meant by the term **free radical**?

(1)

A free radical ~~or~~ is a molecule that has a lone electron making it very reactive

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Examiner Comments

A molecule with a lone electron is not sufficiently precise.

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Examiner Tip

Give only answer to the question.

(a) (i) What is meant by the term **free radical**?

(1)

Very reactive and is an ~~unearn~~ unpaired electron.

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Examiner Comments

A common incorrect response.

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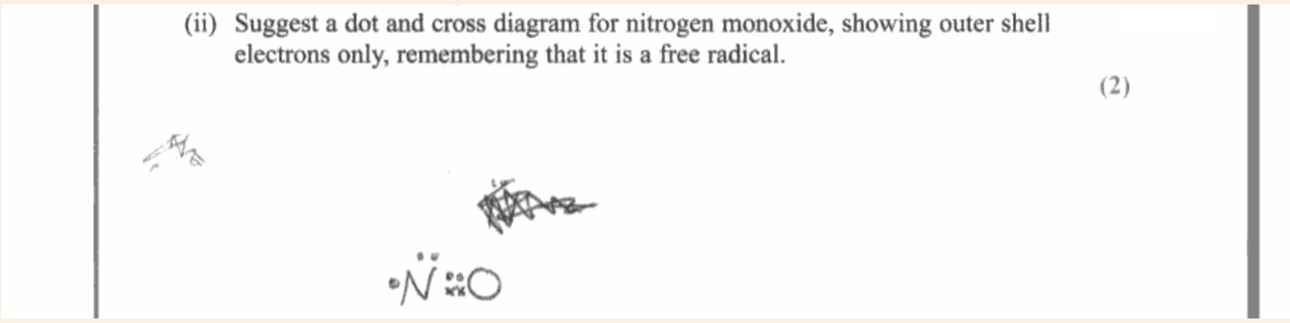
Examiner Tip

Learn precise definitions of chemical terms.

Question 19 (a) (ii)

Many candidates paired one electron from each atom and then could not work out what to do next. Those getting a double bond needed to realise that oxygen would keep both its lone pairs as it is more electronegative, so the unpaired electron is on the nitrogen.


(ii) Suggest a dot and cross diagram for nitrogen monoxide, showing outer shell electrons only, remembering that it is a free radical.

(2)

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Examiner Comments

The non-bonding electrons are missing from the oxygen.

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Examiner Tip
Start any dot and cross answer by drawing each separate atom with its outer electrons.
The oxides of nitrogen are good examples to practise unusual dot and cross diagrams.

Question 19 (b)

Oxidation numbers were not as well done as usual. Silver was often given as the element reduced or, when it was oxidized, it gave ions with up to nine positive charges. Candidates had more success with nitrogen, though positive signs were often missing, and when given must be in front of the number.

Balancing redox equations is a higher level skill at this level, and was achieved by better candidates.

(b) (i) **Part** of the **unbalanced** equation for the preparation of nitrogen monoxide from nitric acid is shown below.

$$Ag(s) + HNO_3(aq) \rightarrow NO(g) + AgNO_3(aq)$$

0   +1 +5 −6   +2 −2   +9 +8 −6

Identify the elements which are oxidized and reduced and give their oxidation numbers.

(3)

Element oxidized ....Ag....

Oxidation number initial ....0.... final ....+9....

Element reduced ....N....

Oxidation number initial ....+5.... final ....+2....

(ii) Complete and balance the equation for the reaction between silver and nitric acid.

(2)

......Ag(s) + ...2... $HNO_3(aq) \rightarrow NO(g)$ + ... $AgNO_3(aq)$ + ...H_2 (g)...

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Examiner Comments

The oxidation number for the silver ion is wrong.
The equation does not balance for oxygen.

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Examiner Tip

Remember, first balance for oxygen by adding water to the side deficient in oxygen, then for hydrogen.

Question 19 (c) (i)

The common weakness was to explain in terms of Le Chatelier's principle, without stating the reaction is endothermic.

(c) The reaction between nitrogen and oxygen to form nitrogen monoxide reaches equilibrium.

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g) \qquad \Delta H^\ominus = +180.4 \text{ kJ mol}^{-1}$$

(i) Explain why the yield of nitrogen monoxide is increased when the temperature is increased.

(1)

temperature has an important effect on reactions, it speeds up making more yield.

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Examiner Comments

This is a common error, confusing yield and rate.

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Examiner Tip

Yield refers to how far, rate to how fast.

Question 19 (c) (ii)

Many candidates said the yield increased instead of decreased.

*(ii) State and explain the effect, if any, on the yield of nitrogen monoxide when the pressure is increased.

(2)

There are the same numbers of gaseous molecules on each side of the equation, so increasing the pressure has no effect on the equilibrium point. Consequently, the yield is not affected.

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Examiner Comments

An excellent answer, relating the lack of change to the number of **gaseous** molecules on each side of the equation.

Question 19 (c) (iii)

Candidates needed to use correct terms in their expression here. Phrases like 'there are more molecules per unit area' rather than volume were common.

There were some very well reasoned answers which failed to state that the rate increased.

(iii) State and explain how the rate of the reaction is affected by an increase in pressure.

(2)

An increase in pressure results in more frequent collisions between molecules, so the reaction rate also increases.

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Examiner Comments

This was a common partial answer, giving increased collision frequency, without explaining why the collision rate increases.

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Examiner Tip

Answer each question as fully as possible.

Question 19 (d) (i)

An explicit statement like jet aeroplanes fly nearer to the ozone layer was needed for the first mark.

There was some confusion about what happens to NO emitted from cars. Many answers referred to it being decomposed rather than reacting with oxygen.

*(d) (i) Explain why a jet aeroplane in flight causes much more damage to the ozone layer than cars carrying the same number of passengers at sea level. You should assume that the nitrogen monoxide outputs for both methods of conveying the passengers are the same.

(2)

The Jet aeroplane will be flying closer to the ozone than the car So the NO will reach to ozone quicker. The NO from the cars may be broken down before it reaches the ozone

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Examiner Comments

NO is not broken down, it reacts with oxygen, so this only gains the first mark.

Question 19 (d) (ii)

Better candidates realised that all they needed to do was to replace Cl by NO in the equations given and add them together to get the overall reaction.

The explanation often correctly stated that NO acted as a catalyst, so one molecule could destroy many thousands of ozone molecules.

(ii) The reactions of chlorine free radicals with ozone may be represented by the following equations.

$$Cl\bullet + O_3 \rightarrow ClO\bullet + O_2$$

$$ClO\bullet + O_3 \rightarrow Cl\bullet + 2O_2$$

Write corresponding equations for the reactions of the free radical nitrogen monoxide with ozone. Combine your two equations to show the overall reaction.

Use these equations to explain why a small quantity of nitrogen monoxide can have a continuing effect on the ozone layer.

(5)

Equations

$$NO\bullet + O_3 \longrightarrow NO_2\bullet + O_2$$

$$NO_2\bullet + O_3 \longrightarrow NO\bullet + 2O_2$$

Overall equation: $2O_3 \rightarrow 3O_2$

Explanation The nitrogen monoxide free radicals are not used up permanently in the reaction, so they can continue to catalyse more instances of the reaction, resulting in many ozone molecules being converted to O_2.

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Examiner Comments

A good answer for full marks.

(ii) The reactions of chlorine free radicals with ozone may be represented by the following equations.

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Write corresponding equations for the reactions of the free radical nitrogen monoxide with ozone. Combine your two equations to show the overall reaction.

Use these equations to explain why a small quantity of nitrogen monoxide can have a continuing effect on the ozone layer.

(5)

Equations

$2NO + 2O_3 \rightarrow 2NO_2 + 2O_2 \quad \times 2$

$NO_2 + O_3 \rightarrow NO + 2O_2$

$2NO + NO_2 \rightarrow 2NO_2 + NO.$

Explanation Even when ozone reacts with NO_2, it gets turned into NO, & the same reactions keep re-occuring & producing NO, which is harmful.

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The doubling of the first equation was acceptable but creates problems later when adding the equations together.
The unpaired electrons are missing from the formulae.
The candidate has not stated that NO is a catalyst.

Paper Summary

Candidates could improve their performance on this unit by:

- Learning the inorganic chemistry of the halogens and alkaline earth metals
- Learning the organic reactions of the alcohols and halogenoalkanes, including the names and formulae of reactants and products.
- Practising drawing apparatus for distillation, reflux, and elimination or cracking.
- Studying bonding and intermolecular forces more carefully so they really understand the principles involved.
- Practising writing ionic and overall equations for reactions met in the unit, and redox equations.

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