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Examiners' Report
June 2019

GCE Chemistry 9CH0 01

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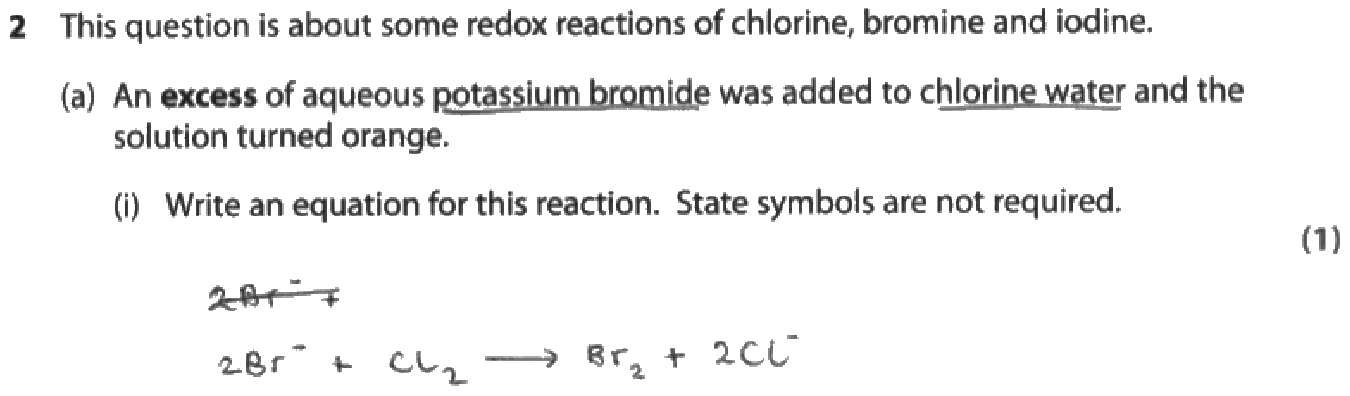
Introduction

This paper proved accessible to all candidates and there was no evidence that any were hindered by not having sufficient time to complete their answers. A number of the questions were found to be demanding and on a few occasions a question required more than one statement to score a single mark. It was pleasing to note that many candidates rose to the challenge and demonstrated their knowledge and understanding of A Level chemistry. Nonetheless, there are some key lessons for centres and candidates to learn from the feedback illustrated in the following examples.

Question 2 (a) (i)

Following the multiple choice questions, this was an accessible question at the start of the question paper and the majority of candidates were awarded the mark. However, in part (i) and the subsequent part (ii) there proved to be some misunderstanding between the terms 'chlorine' and 'chloride' or 'molecular chlorine' and 'chloride ions'.



2 This question is about some redox reactions of chlorine, bromine and iodine.

(a) An **excess** of aqueous potassium bromide was added to chlorine water and the solution turned orange.

(i) Write an equation for this reaction. State symbols are not required.

(1)

~~$2Br^- +$~~

$2Br^- + Cl_2 \longrightarrow Br_2 + 2Cl^-$

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Examiner Comments

An example of a correct ionic equation which was acceptable and was awarded the mark.

$KBr + Cl^- \rightarrow KCl + Br^-$

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Examiner Comments

Although balanced for atoms and for charge, this equation does not score. The question refers to the addition of chlorine and not chloride to potassium bromide.

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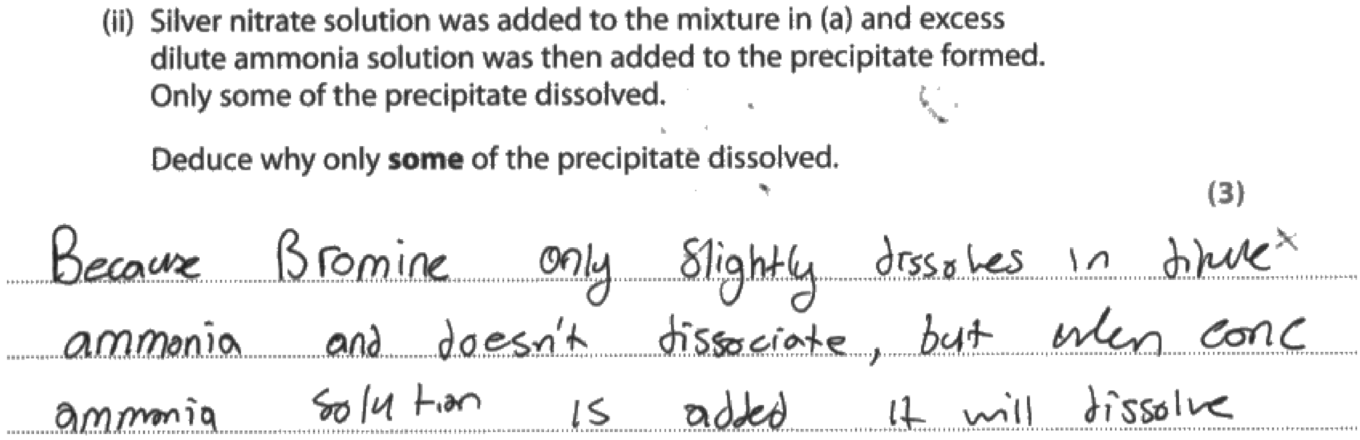
Examiner Tip

Make sure that the terms used in the question are understood before answering the question. This would also be useful practice for revision.

Question 2 (a) (ii)

Many responses referred erroneously to the solubility of molecular halogens rather than their silver precipitates. In addition a significant number of others referred to the solubility of the halide precipitate without mentioning the silver. These errors did result in a loss of credit. This was disappointing as the majority of candidates understood the difference in the solubility between the two compounds in dilute ammonia but did not gain full marks because of such incorrect terminology.



(ii) Silver nitrate solution was added to the mixture in (a) and excess dilute ammonia solution was then added to the precipitate formed. Only some of the precipitate dissolved.

Deduce why only **some** of the precipitate dissolved.

(3)

Because Bromine only slightly dissolves in dilute× ammonia and doesn't dissociate, but when conc ammonia solution is added it will dissolve

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Examiner Comments

This is an example of a response where the term 'bromine' was used which is incorrect. The precipitate was a 'bromide' and this difference is significant because bromine is a diatomic molecule whereas bromide is an ion. The response also refers to the use of concentrated ammonia but this was not part of the question and therefore, is irrelevant. This response scored zero.

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Examiner Tip

Do make sure that the correct term for the species is used.

Deduce why only **some** of the precipitate dissolved.

→ (not fully complete → KBr left over)

(3)

Reaction at equilibrium so Silver nitrate forms precipitate with both Bromine and Iodine.

Chlorine precipitate dissolves in dilute ammonia while Bromine precipitate does not (only Conc ammonia)

↳ only some ~~ppt~~ precipitate dissolves

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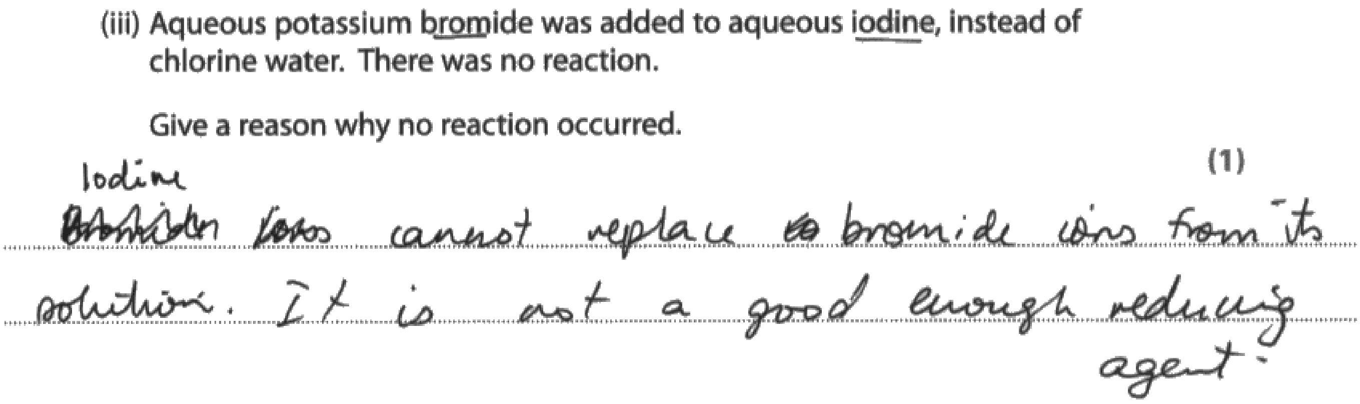
Examiner Comments

Another example of a response where the incorrect halogen term is used. However, the overall response is making the correct comparison between the silver chloride dissolving but the silver bromide not dissolving in dilute ammonia. There is also reference to some 'Br' being left over after the addition of the chlorine water. In essence, a single error in the use of terms has been made and so was penalised once.

Question 2 (a) (iii)

A significant number of responses simply referred to the inability of iodine to displace bromide or that it is less reactive but this question requires 'a reason'. Hence, a successful response needed to either refer to iodine being a weaker oxidising agent than chlorine or being too strong a reducing reagent.



(iii) Aqueous potassium bromide was added to aqueous iodine, instead of chlorine water. There was no reaction.

Give a reason why no reaction occurred.

(1)

Iodine

[illegible] [illegible] cannot replace [illegible] bromide ions from its solution. It is not a good enough reducing agent.

ResultsPlus
Examiner Comments

The first sentence of this response can be ignored. The second sentence is referring to the correct concept but unfortunately is the wrong way round. The correct answer is that iodine is a stronger reducing agent and hence this response does not score.

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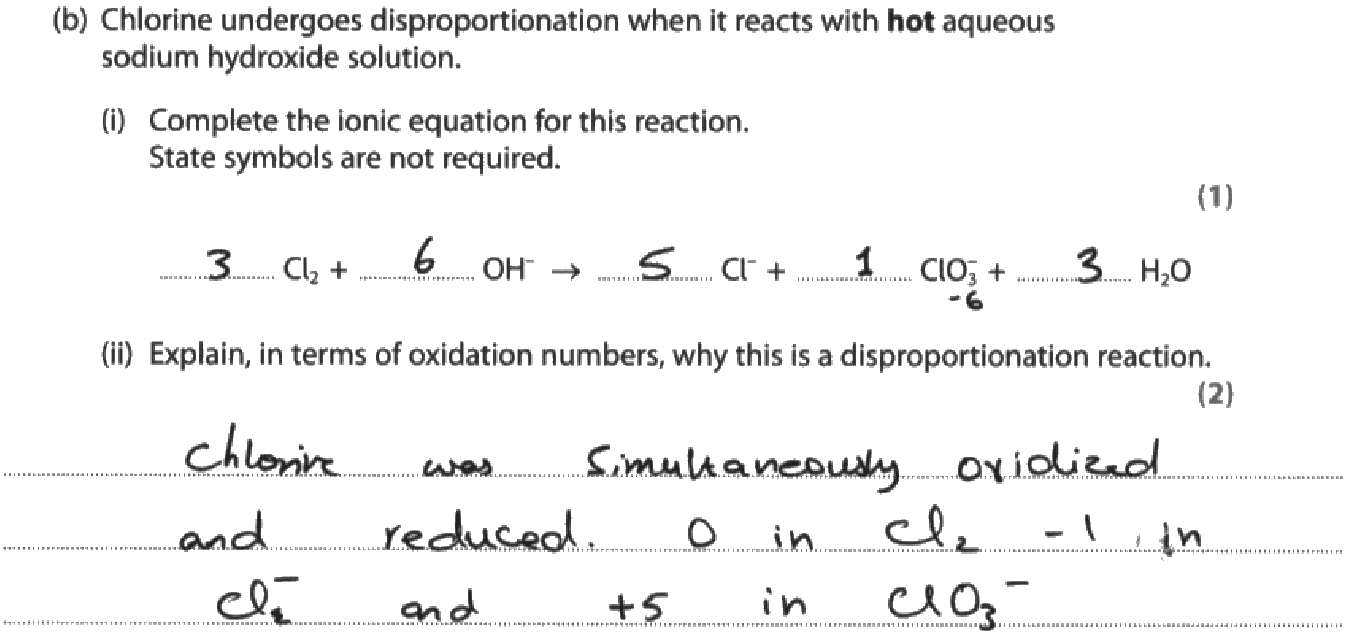
Examiner Tip

Take extra time to carefully think through whether oxidation (loss of electrons) or reduction (gain of electrons) is the issue.

Question 2 (b)

The balancing of the equation in part (i) was a question of high demand and gave an opportunity for the high ability candidates to demonstrate their understanding. This type of question is worth practicing and the oxidation number changes do provide a useful way of succeeding in this.

The oxidation number changes were identified very well with the majority of candidates correctly stating these. However, the requirement for these oxidation number changes was in the context of disproportionation and so these changes needed to be correctly linked with the relevant terms of oxidation and reduction which was not always done.



(b) Chlorine undergoes disproportionation when it reacts with **hot** aqueous sodium hydroxide solution.

(i) Complete the ionic equation for this reaction.
State symbols are not required.

(1)

3 Cl_2 + 6 OH^- → 5 Cl^- + 1 ClO_3^- + 3 H_2O

-6

(ii) Explain, in terms of oxidation numbers, why this is a disproportionation reaction.

(2)

Chlorine was simultaneously oxidized and reduced. 0 in Cl_2 -1 in Cl^- and +5 in ClO_3^-

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Examiner Comments

Part (i) has been completed correctly and gains the mark.

Part (ii) correctly states the oxidation number changes but the terms oxidation and reduction needed to be linked with these changes. In this instance, the term 'oxidised' is used first and then followed by 'reduced' and so the oxidation number changes should follow this order but unfortunately they don't. Hence, one mark and not two was awarded.

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Examiner Tip

Make sure that any oxidation number change is correctly linked with the appropriate term of oxidation or reduction.

(i) Complete the ionic equation for this reaction.
State symbols are not required.

2Cl 4O 4H   2Cl 4O 4H

(1)

$\dots 1\ Cl_2 + \dots \overset{2}{\cancel{4}}\ OH^- \rightarrow \dots 1\ Cl^- + \dots 1\ ClO_3^- + \dots 2\ H_2O$

-1   +5

(ii) Explain, in terms of oxidation numbers, why this is a disproportionation reaction.

(2)

Chlorine is both oxidised and reduced.

- reduction

0 → -1

- oxidation

0 → +5

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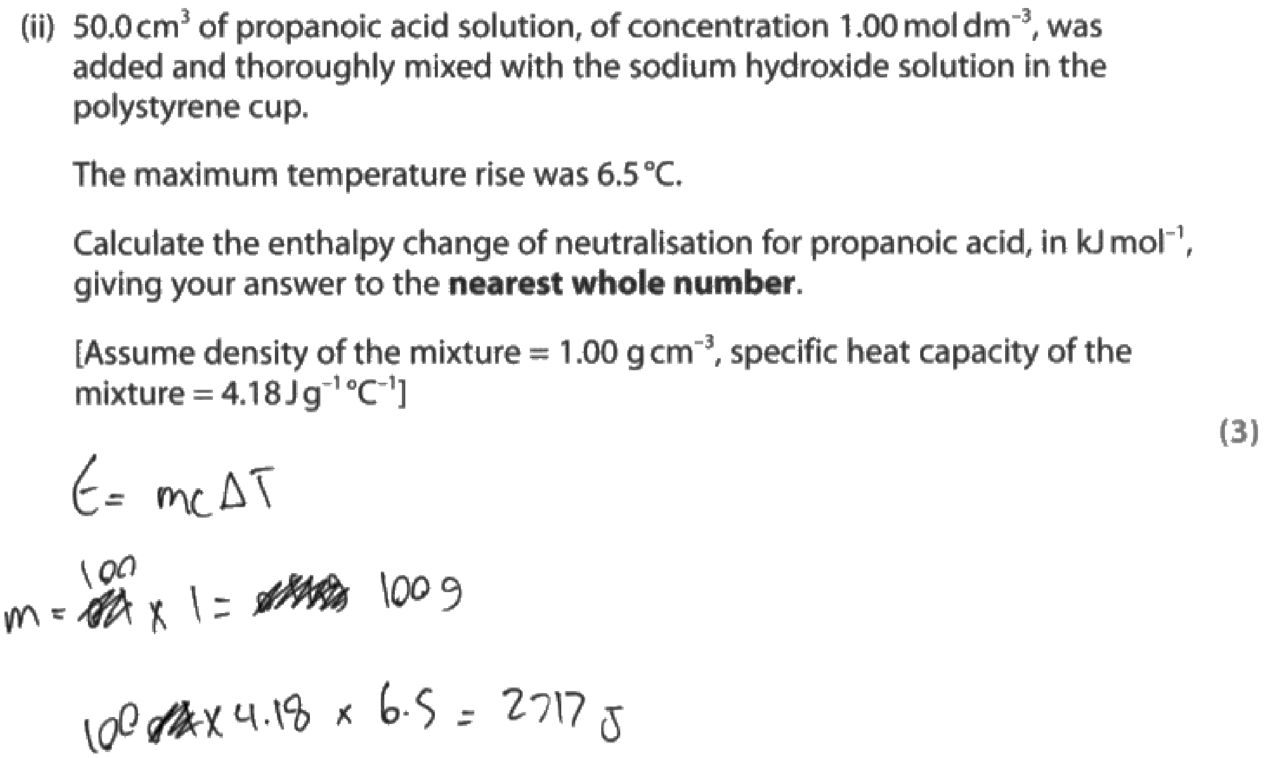
Examiner Comments

Part (i) the equation is not correctly completed and so no credit was given.

Part (ii) of this response has the general definition of disproportionation initially given but then the oxidation number changes are correctly linked to reduction and then to oxidation. Hence both marks are awarded.

Question 3 (a) (ii)

A full range of marks from 0 to 3 were awarded for this question and so, differentiated well. A significant number of candidates missed the fact that the total volume in the polystyrene cup was 100 cm^3 because two volumes of 50 cm^3 were added together. Nevertheless, candidates could gain credit for the remainder of the calculation. A useful reminder is to note the requirement in the question to give the final answer to the "nearest whole number", which is given in bold text. Therefore, this is an essential requirement and some candidates lost credit for giving their answer to a number of decimal places.



(ii) 50.0 cm^3 of propanoic acid solution, of concentration 1.00 mol dm^{-3}, was added and thoroughly mixed with the sodium hydroxide solution in the polystyrene cup.

The maximum temperature rise was 6.5 °C.

Calculate the enthalpy change of neutralisation for propanoic acid, in kJ mol^{-1}, giving your answer to the **nearest whole number**.

[Assume density of the mixture = 1.00 g cm^{-3}, specific heat capacity of the mixture = 4.18 J g^{-1} °C^{-1}]

(3)

$E = mc\Delta T$

$m = \overset{100}{\cancel{50}} \times 1 = 100\,g$

$100 \times 4.18 \times 6.5 = 2717\ J$

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Examiner Comments

The use of the symbol 't' was a concern but ignored in this instance. The calculation of Q or heat was correctly carried out and so scored one mark. There has been no attempt at converting the value into the enthalpy change so no further credit can be awarded.

ResultsPlus
Examiner Tip

It is always worthwhile attempting a calculation even if it cannot be completed because some credit may be able to be obtained.

$$\text{Enthalpy changes} = \frac{\text{Energy (KJ)}}{\text{moles}}$$

① $Q = mc\Delta T$

$50 \times 4.18 \times 6.5 = 1358.5\ J$

② $\text{moles} = 50/1000 \times 1 = 0.05$

③ $$\frac{1358.5/1000}{0.05}$$

$= 27.17$

$= \boxed{27\ KJmol^{-1}}$

ResultsPlus
Examiner Comments

This response has carried out the calculation of enthalpy change but made two significant errors. The first is to use a mass of 50 instead of 100 and so the first mark is lost. Transferred error can be applied and so the remainder of the calculation does gain credit and scores the second mark. However the third mark is awarded for the answer given to the nearest whole number, which in this instance is correct, and the use of a **negative sign** because the reaction is exothermic. Alas, in this response there is no such negative sign so this third mark is not awarded.

Hence this response scores one mark.

Question 3 (b) (ii)

The majority of candidates correctly stated that ethanoic acid is a weak acid or that it was only partially ionised/dissociated for the first mark. The second mark required an explanation for the reason why the enthalpy of neutralisation was less exothermic and this was very discriminating. The more discerning candidate appreciated that energy is required to fully ionise the weak acid or that energy is required to break the O-H bond which results in a less exothermic enthalpy change.

(ii) Explain why the data book value for the standard enthalpy change of neutralisation of ethanoic acid with sodium hydroxide is $-55.2\ \text{kJ mol}^{-1}$ but the value for hydrochloric acid is $-57.1\ \text{kJ mol}^{-1}$.

(2)

Ethanoic acid is a weak acid (does not dissociate completely in aqueous solution) while HCl is a strong one (dissociates almost completely) so a reaction between a strong acid (HCl) strong alkali (NaOH) will release more energy than with ethanoic acid.

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Examiner Comments

One mark is scored for this response correctly identifying the fact that ethanoic acid is a weak acid and not fully disassociated. However, the second mark for how this explains the lower enthalpy change of neutralisation is not addressed.

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Examiner Tip

In an 'explain' question make sure that after making a statement that a reason or justification is given in the explanation.

-Hydrochloric acid is a strong acid that completely dissociates to its ions, this causes it to have a ΔH_N value of $-57.1\ kJ\,mol^{-1}$, meanwhile ethanoic acid is a weak acid and it only partially dissociates therefore it needs energy to undergo complete dissociation giving it a higher ΔH_N value.

(Total for Question 3 = 7 marks)

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Examiner Comments

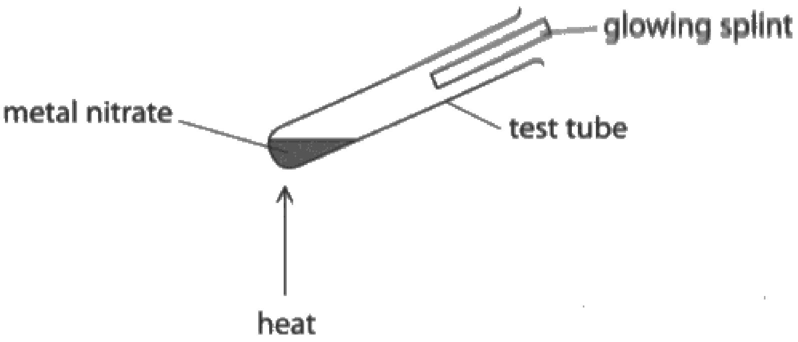
This response does make both points which are required, namely that ethanoic acid is a weak acid and energy is required to complete dissociation. The reference at the end of the response was taken to apply to the hydrochloric acid stated at the start of the response, otherwise this could have negated the correct explanation.

Question 4 (a) (i)

Two correct statements were required for one mark in this question because this is a topic which is learnt at GCSE level. Nonetheless a sigificant minority were unable to correctly give both parts, either giving the correct gas or the correct positive result of the test, and this did not score the mark.

4 Thermal decomposition is the breaking down of a substance by heat.

(a) An experiment was carried out to investigate the thermal decomposition of a metal nitrate using the apparatus shown.



(i) The glowing splint is used as a test for one of the gases given off in this experiment.

Identify this gas and the positive result of the test.

(1)

Hydrogen, splint will relight

ResultsPlus
Examiner Comments

The correct positive result of the test is given but the identity of the gas is incorrect. Hence this response gained no credit.

(1)

Oxygen gas, a popping sound as It combusts

ResultsPlus
Examiner Comments

The gas is correctly identified but the result of the test given is for a different gas, namely hydrogen. Hence no mark was given for this response.

(1)

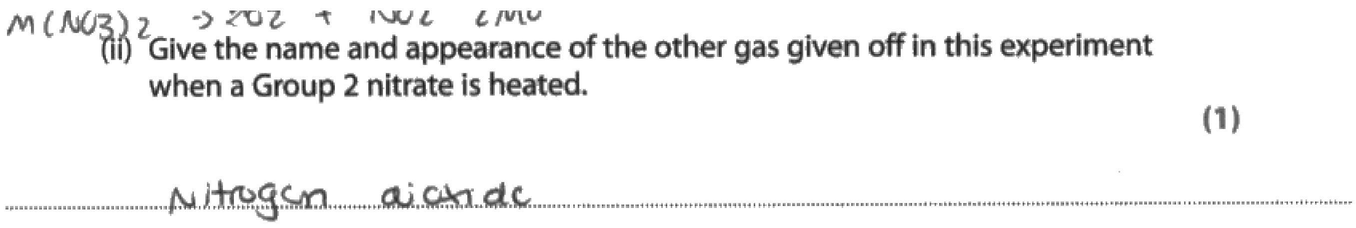
Oxygen and it will relight the glowing splint.

ResultsPlus
Examiner Comments

An example of a successful response which correctly identifies the gas and the positive result of the test.

Question 4 (a) (ii)

Another question reflecting the higher demand of A Level as two parts are required for the one mark. Centres would be well-advised to continually remind their candidates that if a name and formula are given then both must be correct. This principle applied throughout this paper and did have an impact on this question with some candidates attempting to give the formula as well as the name of the gas. If the formula was incorrect then this would negate the mark.



$M(NO_3)_2 \rightarrow 2O_2 + NO_2$ 2MO

(ii) Give the name and appearance of the other gas given off in this experiment when a Group 2 nitrate is heated.

(1)

Nitrogen dioxide

ResultsPlus
Examiner Comments

No credit was given for just the name.

ResultsPlus
Examiner Tip

Make sure that if the question requires two parts for one mark that both are given.

NO_2 / nitric oxide smokey fumes.

ResultsPlus
Examiner Comments

The appearance is incorrect and so this response would not score. Note that the name of the gas is incorrect and so would not gain the mark anyway.

ResultsPlus
Examiner Tip

Learn the correct names for the common gases.

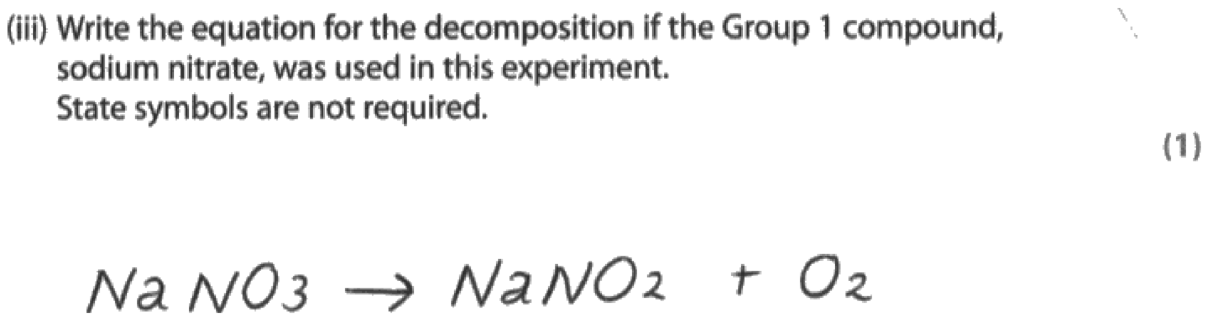
~~Ni~~ Nitrogen dioxide which is a brown gas

ResultsPlus
Examiner Comments

An example of a correct response which scored the mark.

Question 4 (a) (iii)

Only about a third of all candidates could correctly give a balanced equation for this question. Both this topic area and this skill of balancing equations is worthy of repeated practice.



(iii) Write the equation for the decomposition if the Group 1 compound, sodium nitrate, was used in this experiment.
State symbols are not required.

(1)

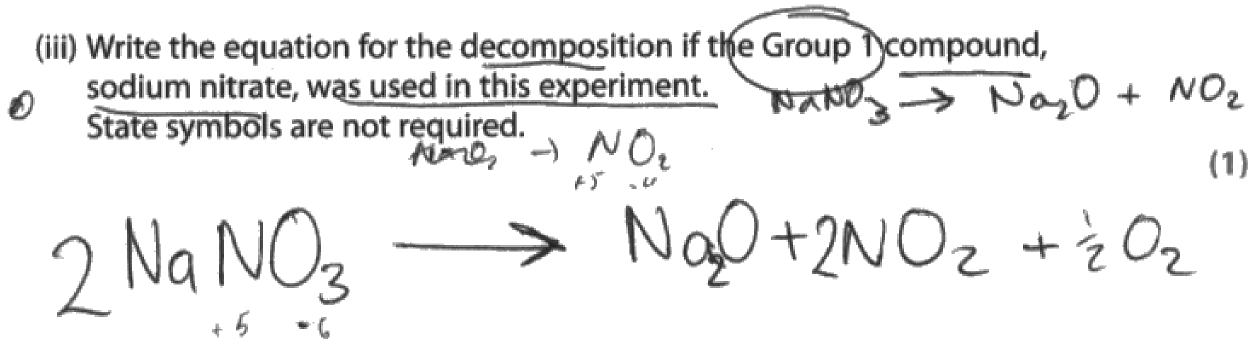
$NaNO_3 \rightarrow NaNO_2 + O_2$

ResultsPlus
Examiner Comments

This response has an equation with the correct formulae of the species but is not balanced. Hence it does not gain the mark.

ResultsPlus
Examiner Tip

Time is well-spent double-checking equations to make sure that they balance for atoms and for charge.



0

(iii) Write the equation for the decomposition if the Group 1 compound, sodium nitrate, was used in this experiment.
State symbols are not required.

(1)

$NaNO_3 \rightarrow Na_2O + NO_2$

$NaNO_3 \rightarrow NO_2$

+5 +4

$2NaNO_3 \longrightarrow Na_2O + 2NO_2 + \frac{1}{2}O_2$

+5 −6

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Examiner Comments

This is an example of an equation which is balanced for atoms. Unfortunately, the species are incorrect and so does not score. A reminder that the chemistry of a topic must be clearly learnt.

$$2NaNO_3 \xrightarrow[\Delta]{} 2NaNO_2 + O_2$$

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Examiner Comments

An example of a correct response.

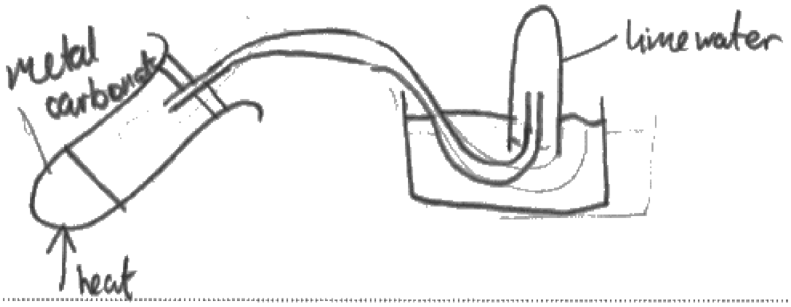
Question 4 (a) (iv)

A large number of candidates approached this question by referring to the collection of gas either with a gas syringe or by water displacement. However, this is not the method that would be used and so lost the first mark but the second mark for how a comparison could be made was possible.

The space provided allowed for candidates to respond with either a diagram or by prose. Many diagrams of the apparatus proposed were not drawn with sufficient care as the following examples illustrate. Centres and candidates would benefit from repeated practice from such activity.

(iv) Describe the apparatus that would be used to compare the decomposition of metal carbonates. Include how the rate of decomposition would be compared.

(2)



Measure the time taken for the limewater to go cloudy

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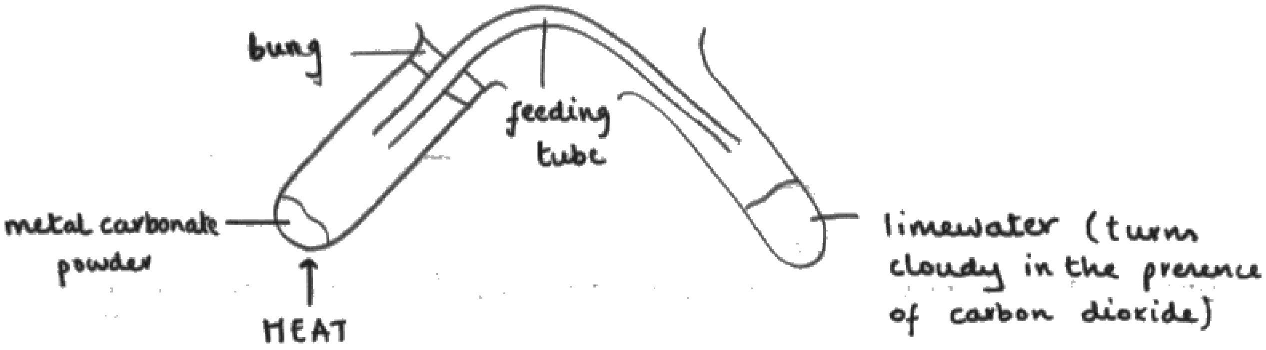
Examiner Comments

An example of a response to help centres and candidates appreciate and avoid errors in apparatus drawing:

- The delivery tube is extended above the fluid level in the beaker or trough.
- There is no liquid in the inverted tube into which the delivery tube extends.
- The limewater label is to the tube and not a solution.

Hence this response did not score the first mark but the second mark was given for how the comparison would be made.



You can use two ~~test~~ boiling ~~tt~~ tubes, one containing the metal carbonate in a powdered form, with a feeding tube leading to a tube of limewater. The ~~dt~~ rate of decomposition could be measured by measuring the time taken for the limewater to turn cloudy as carbon dioxide evolves and ~~as~~ a white precipitate forms. A graph could then be plotted.

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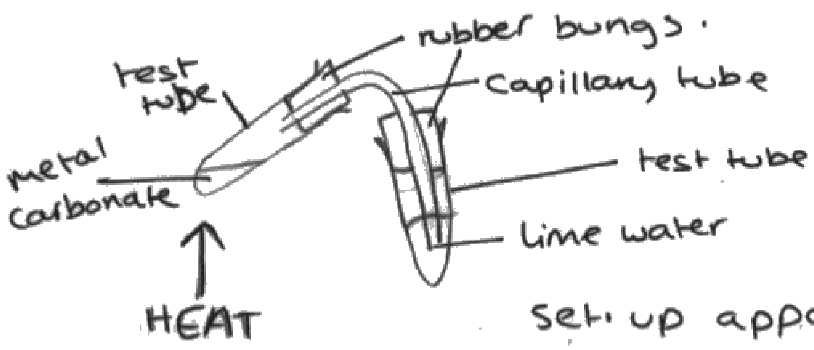
Examiner Comments

Another example of an incorrect apparatus diagram:

- Note that the delivery tube does not extend into the limewater and so would not result in it turning cloudy.

(2)



set up apparatus as above.

start a timer as heat is applied to metal carbonate then stop it as soon as the lime water turns cloudy.

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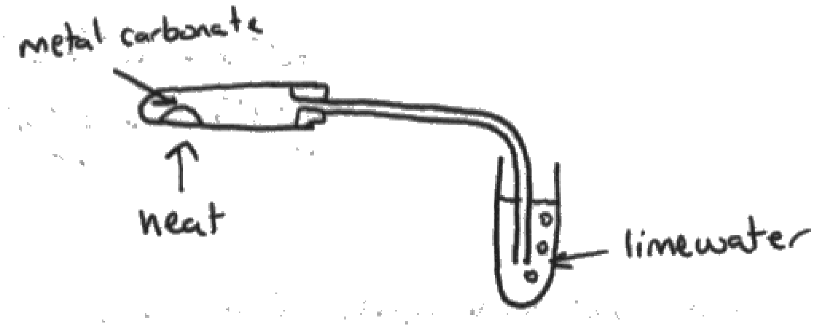
Examiner Comments

A third and final example of a typical error in the experimental apparatus setup:

- The rubber bung in the test tube with the limewater would be dangerous as pressure would build up with the production of gas.

(2)



The rate of decomposition would be ~~measured by~~ compared by comparing the time taken for the limewater to go cloudy enough that it can't be seen through.

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Examiner Comments

A correctly drawn apparatus which, with a suitable comment for how to compare rate of decomposition, scored both marks.

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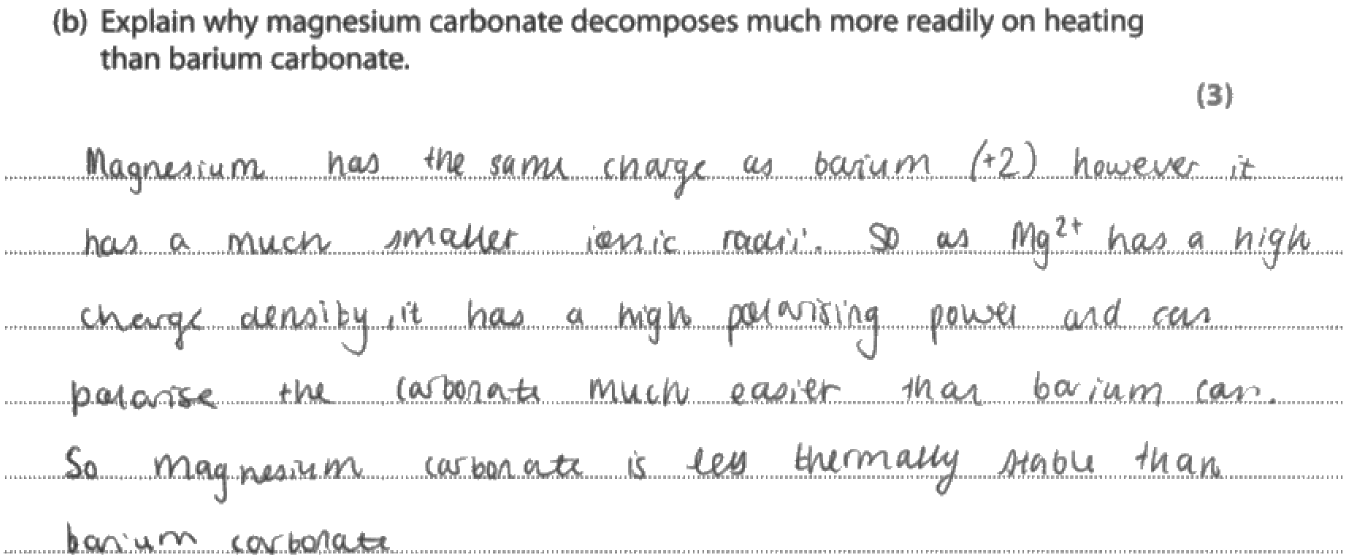
Examiner Tip

Practice drawing experimental apparatus. It is time well-spent.

Question 4 (b)

A sizeable number of candidates gave an excellent answer scoring all three marks which was pleasing and showed that these had learnt and understood this topic area very well. The lack of precision by some candidates such as by referring to the metal rather than the metal cation occasionally resulted in a loss of marks. Another common error was seen in the lack of clarity in the effect of polarisation on the carbonate ion. It was common to see a vague response stating that the carbonate bond was weakened but this could be the ionic bond between the carbonate and the metal cation instead of the bonds within the carbonate ion. Hence this vagueness was not credited.



(b) Explain why magnesium carbonate decomposes much more readily on heating than barium carbonate.

(3)

Magnesium has the same charge as barium (+2) however it has a much smaller ionic radii. So as Mg^{2+} has a high charge density, it has a high polarising power and can polarise the carbonate much easier than barium can. So magnesium carbonate is less thermally stable than barium carbonate

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Examiner Comments

This response correctly makes the first two marking points. The smaller magnesium ion with the higher charge density is stated and its greater polarisation of the carbonate ion. There is no reference to the effect that this has on the bonds within the carbonate ion for the third mark.

(b) Explain why magnesium carbonate decomposes much more readily on heating than barium carbonate.

(3)

Magnesium Mg^{2+} has a smaller ionic radius than Ba^{2+}, so it has a greater charge density. Even though Ba^{2+} has a larger nuclear charge, the shielding effect is the predominant factor. This means Mg^{2+} is more polarising than Ba^{2+} so it distorts the charge cloud of the CO_3, weakening the carbon to oxygen bond. This means it requires less energy to break into CO_2 + MO as the CO_3 is more ~~pl~~ polarised. ∴ $MgCO_3$ decomposes more readily

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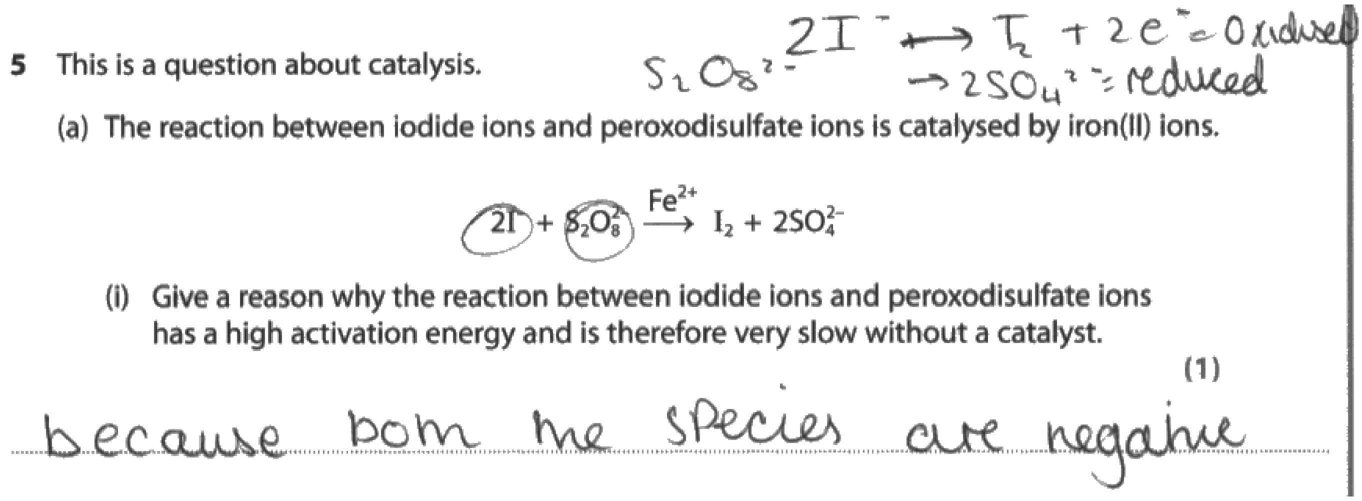
Examiner Comments

An example of a response which makes all three marking points clearly and without contradiction.

Question 5 (a) (i)

This was another question where two parts of the answer were both required for the mark. The first part was the straightforward identification of the negative charge on both species. The second part was in response to the question requiring a reason for the very slow reaction, namely that the two species would repel each other. This two-part level of demand served to differentiate well and highlights the high demand of A Level.



5 This is a question about catalysis.

$S_2O_8^{2-}$ $2I^- \rightarrow I_2 + 2e^-$ = Oxidised

$\rightarrow 2SO_4^{2-}$ = reduced

(a) The reaction between iodide ions and peroxodisulfate ions is catalysed by iron(II) ions.

$$2I^- + S_2O_8^{2-} \xrightarrow{Fe^{2+}} I_2 + 2SO_4^{2-}$$

(i) Give a reason why the reaction between iodide ions and peroxodisulfate ions has a high activation energy and is therefore very slow without a catalyst.

(1)

because both the species are negative

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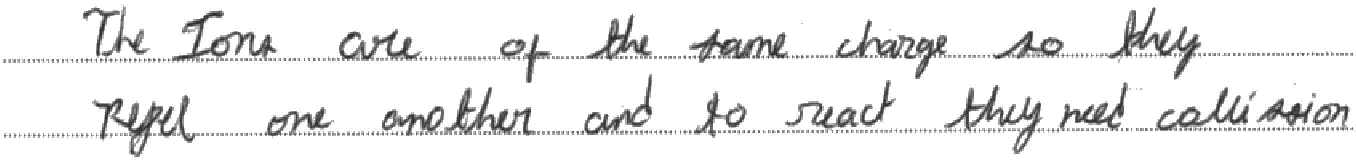
An example of a response which only identifies that both species are negative but fails to give the reason for the very slow reaction rate.



The Ions are of the same charge so they repel one another and to react they need callision

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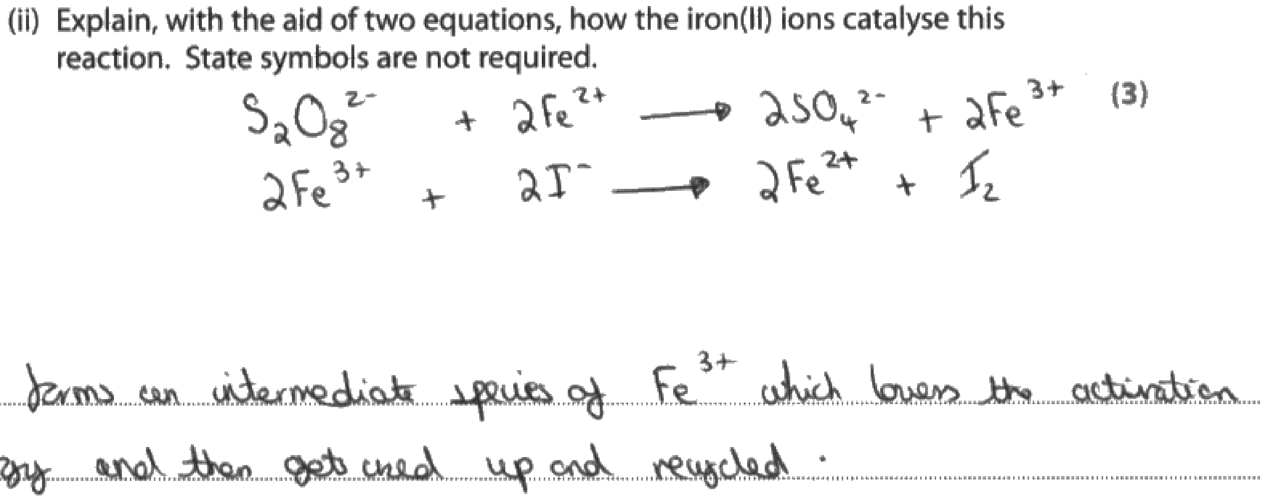
An example of a suitable response which scored the mark.

Question 5 (a) (ii)

This question proved to be another effective discriminator by producing the full range of marks. Almost half of all candidates scored zero, which suggests that homogenous catalysis would be a useful area for consolidation by centres and candidates.

Many candidates got the stoichiometry wrong, again highlighting the need to practice balancing equations. A significant number of candidates gave the equations in the wrong order. The question specifically stated that iron(II) ions were the catalyst and so these should have been used to start the process. However, one mark out of the first two was awarded if this was the approach.

A reasonable number of candidates correctly followed on from the question in (i), where the slow reaction was due to the same charges repelling and wrote an explanation for the catalysis by iron (II) ions due to their opposite charge to the reacting species. This was pleasing to see and showed initiative by those candidates. An alternative approach was to refer to the typical property of transition elements of variable oxidation state which was also acceptable.



(ii) Explain, with the aid of two equations, how the iron(II) ions catalyse this reaction. State symbols are not required.

(3)

$$S_2O_8^{2-} + 2Fe^{2+} \longrightarrow 2SO_4^{2-} + 2Fe^{3+}$$

$$2Fe^{3+} + 2I^- \longrightarrow 2Fe^{2+} + I_2$$

It forms an intermediate species of Fe^{3+} which lowers the activation energy and then gets used up and recycled .

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Examiner Comments

This response scores two marks for two correct equations.

However the explanation does not score. There is no reference either to the variable oxidation state of the iron nor to the difference in the species compared to that noted in part (i) of this question.

(ii) Explain, with the aid of two equations, how the iron(II) ions catalyse this reaction. State symbols are not required.

(3)

$$2I^- + 2Fe^{2+} \rightarrow I_2 + 2Fe^{\text{[illegible]}+}$$

$$2Fe^{+} + S_2O_8^{2-} \rightarrow 2Fe^{2+} + 2SO_4^{2-}$$

This is faster as iron positively charged

so attracts to negative reactants.

ResultsPlus

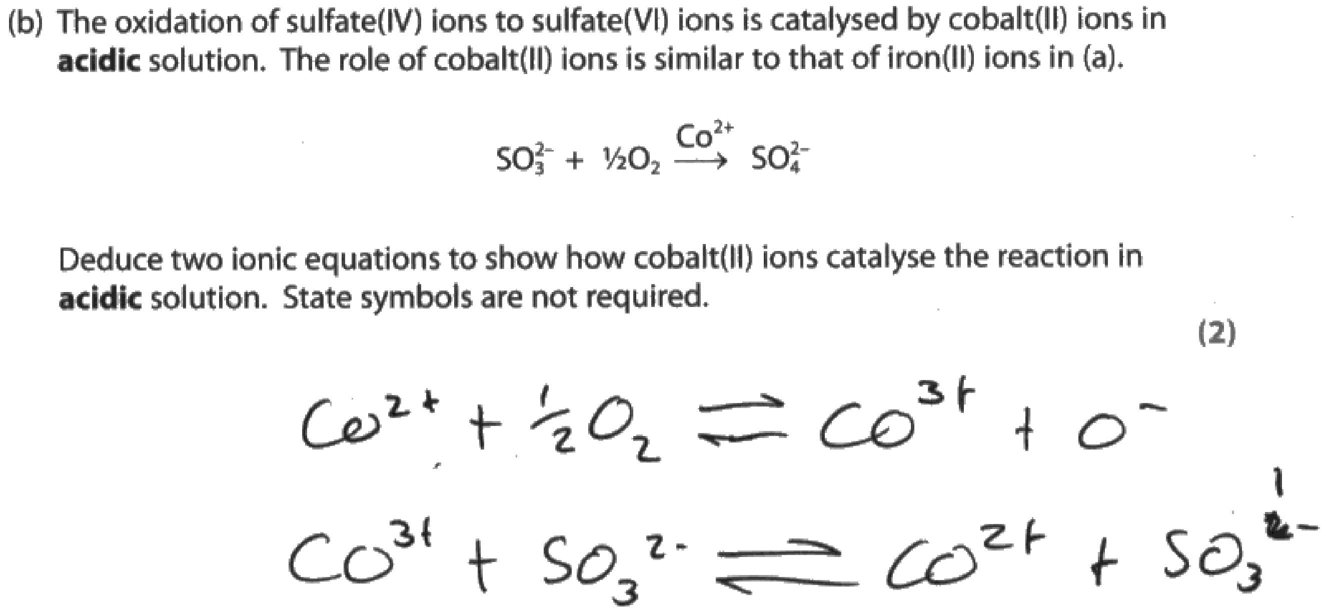
Examiner Comments

The comment scores one mark and is a clear follow-on from the answer to part (i). This was acceptable.

Unfortunately the equations did not score. The two equations were viewed as two separate entities and so no transferred error was applied.

Question 5 (b)

This question proved to be the most challenging on the whole paper. It was designed to be a follow-on from the previous question and provide another example of where the variable oxidation states of transition elements often enables catalytic activity. Many candidates used the space provided to try and work out the answer but often has missed the reference in the question, which had been highlighted in bold, that the reaction took place in "acidic" conditions. This was the key to obtaining correct equations and is a useful reminder of the emphasis that candidates need to note from words given in bold text.



(b) The oxidation of sulfate(IV) ions to sulfate(VI) ions is catalysed by cobalt(II) ions in **acidic** solution. The role of cobalt(II) ions is similar to that of iron(II) ions in (a).

$$SO_3^{2-} + ½O_2 \xrightarrow{Co^{2+}} SO_4^{2-}$$

Deduce two ionic equations to show how cobalt(II) ions catalyse the reaction in **acidic** solution. State symbols are not required.

(2)

$$Co^{2+} + \tfrac{1}{2}O_2 \rightleftharpoons Co^{3+} + O^{-}$$

$$Co^{3+} + SO_3^{2-} \rightleftharpoons Co^{2+} + SO_3^{\overset{1}{\cancel{2}}-}$$

ResultsPlus
Examiner Comments

An example of a response which does not score. A reminder that although an equation may balance for atoms and charge it still must include correct chemical species. The first equation given by this candidate illustrates this. The equation does balance for both atoms and charge but the oxide ion is not an appropriate species so does not score.

The second equation does not form the sulfate (VI) ion and is missing other necessary species.

(b) The oxidation of sulfate(IV) ions to sulfate(VI) ions is catalysed by cobalt(II) ions in **acidic** solution. The role of cobalt(II) ions is similar to that of iron(II) ions in (a).

$$\underset{+4}{\underset{\downarrow}{SO_3^{2-}}} + \tfrac{1}{2}O_2 \xrightarrow{Co^{2+}} \underset{+6}{\underset{\downarrow}{SO_4^{2-}}}$$

Deduce two ionic equations to show how cobalt(II) ions catalyse the reaction in **acidic** solution. State symbols are not required.

(2)

~~$H_2O + SO_3^{2-} + 2Co^{2+} \rightarrow SO_4^{2-} + 2Co^{3+} + 2H^+$~~ [illegible]

$2H^+ + 2Co^{2+} + \frac{1}{2}O_2 \rightarrow 2Co^{3+} + H_2O$

$H_2O + SO_3^{2-} + 2Co^{3+} \rightarrow SO_4^{2-} + 2H^+ + 2Co^{2+}$

ResultsPlus
Examiner Comments

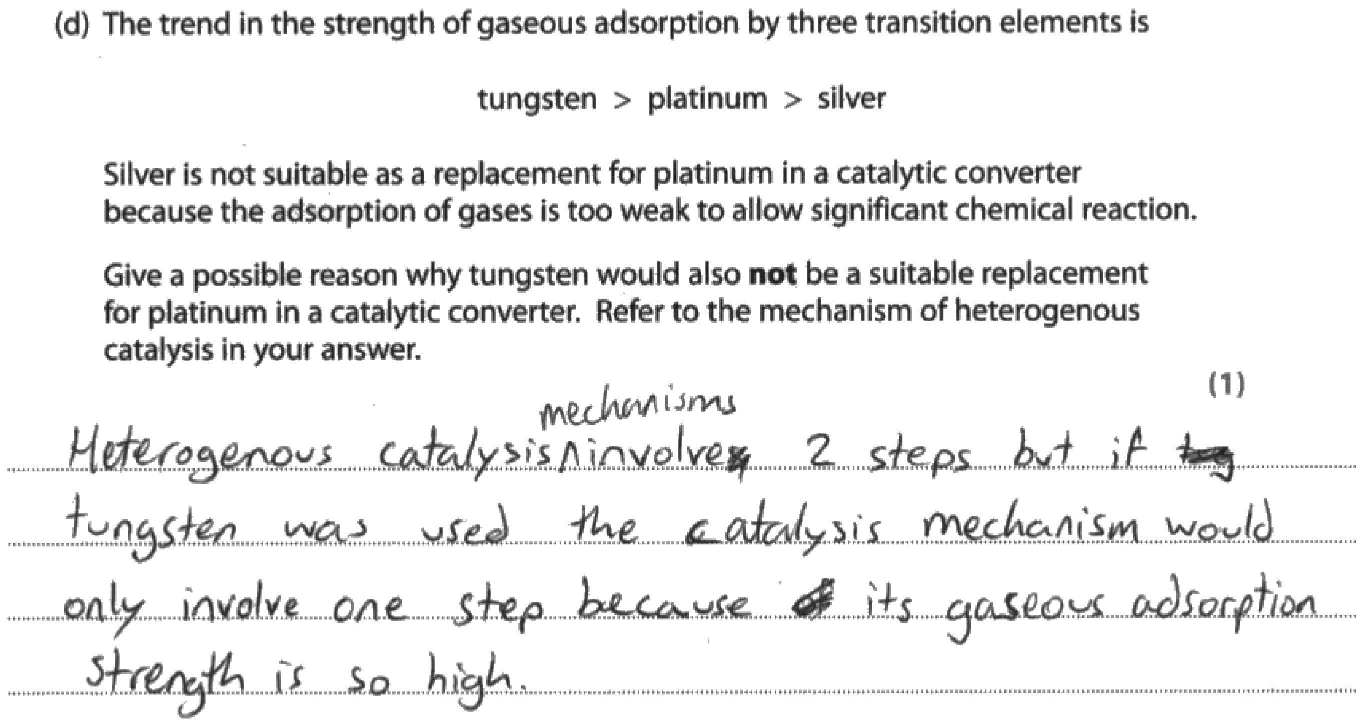
An example of a correct response.

ResultsPlus
Examiner Tip

Working out or trial work can be crossed out and ignored when replaced by the final answer as shown here.

Question 5 (d)

This question specifically states that reference to the mechanism of heterogeneous catalysis be provided in the answer and so mention was required of adsorption and desorption. It was pleasing to see very few references to 'absorption' and so centres and candidates are to be commended for this. However, it was not uncommon for candidates to refer to just one stage of catalysis without giving a reason for the fact that tungsten would not be a suitable catalyst.



(d) The trend in the strength of gaseous adsorption by three transition elements is

tungsten > platinum > silver

Silver is not suitable as a replacement for platinum in a catalytic converter because the adsorption of gases is too weak to allow significant chemical reaction.

Give a possible reason why tungsten would also **not** be a suitable replacement for platinum in a catalytic converter. Refer to the mechanism of heterogenous catalysis in your answer.

(1)

Heterogenous catalysis mechanisms involve~~s~~ 2 steps but if ~~tu~~ tungsten was used the catalysis mechanism would only involve one step because ~~o~~ its gaseous adsorption strength is so high.

ResultsPlus
Examiner Comments

This candidate correctly deduces that an issue is the strength of adsorption but does not go on to state that the consequence is that desorption would be too slow or prevented. The reference to only one reaction or one step happening is not equivalent.

tungsten would be able to adsorb gases so they can react on the surface of the catalyst but the gases may not be able to desorb from the catalyst surface as the adsorption was too strong

(Total for Question 5 = 8 marks)

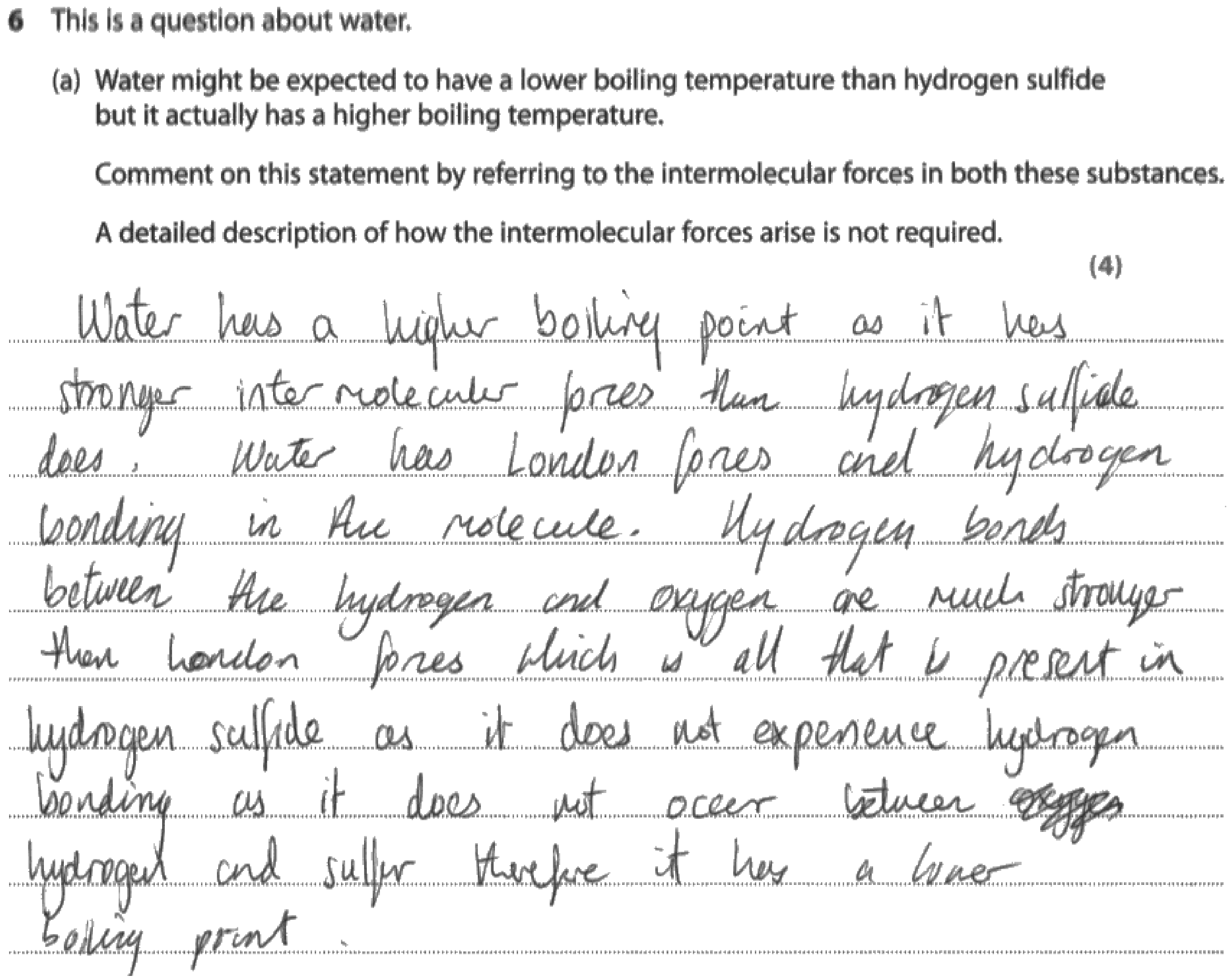
ResultsPlus

Examiner Comments

An example of a correct response.

Question 6 (a)

The full range of marks was awarded for this question, with only a small number of candidates scoring zero. There were some lengthy responses which largely failed to address the necessary points and often only scored one mark for the reference to the hydrogen bonding between water molecules. There was some difficulty or possible evidence of some confusion in candidates' minds, between intramolecular covalent bonds and intermolecular forces. Centres and their candidates are well-advised to take care when referring to the breaking of bonds so that it is clear that the intermolecular forces are being broken and not the covalent bonds.



6 **This is a question about water.**

(a) **Water might be expected to have a lower boiling temperature than hydrogen sulfide but it actually has a higher boiling temperature.**

Comment on this statement by referring to the intermolecular forces in both these substances.

A detailed description of how the intermolecular forces arise is not required.

(4)

Water has a higher boiling point as it has stronger inter molecular forces than hydrogen sulfide does. Water has London forces and hydrogen bonding in the molecule. Hydrogen bonds between the hydrogen and oxygen are much stronger than London forces which is all that is present in hydrogen sulfide as it does not experience hydrogen bonding as it does not occur between ~~oxygen~~ hydrogen and sulfur therefore it has a lower boiling point.

ResultsPlus
Examiner Comments

This response only addresses one of the points raised in the question, namely the fact that water has a higher boiling temperature than hydrogen sulfide. The reference to the presence of hydrogen bonding in water scores a mark but there is no reference to the additional "energy" required to break these on boiling, which is the reason for the higher boiling temperature. Hence only one of the two marks available for this half of the answer is awarded.

Oxygen is a more electronegative atom than sulphur. H_2S does have more electrons so its will experience greater amounts of London forces but the increased polarity in the O - H bond means that there is greater permanent dipole - dipole attraction and stronger Hydrogen bonding as there is a greater difference in charge between H and O atoms in different water molecules. Permanent dipole - dipole attraction and hydrogen bonding are both stronger types of intermolecular forces compared to London forces so they have a greater effect, hence water requires more energy for its intermolecular forces to be overcome for it to boil.

ResultsPlus
Examiner Comments

This response does address both aspects required in the question. There is mention in the beginning of the response how hydrogen sulfide has more electrons and therefore greater London forces than water, which is the reason why it might be expected that hydrogen sulfide would have the higher boiling temperature. This gains the first two marks.

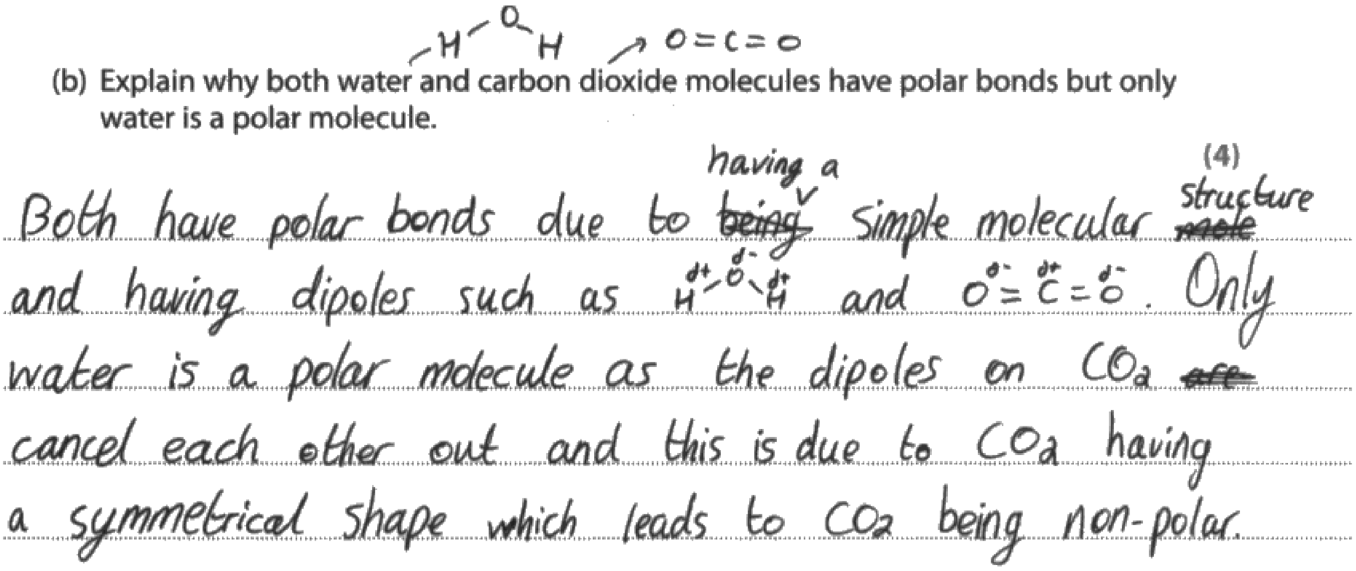
The response then goes on to refer to water having hydrogen bonding which is the stronger intermolecular force and requires more energy to break on boiling. Hence a further two marks are awarded.

This means that this response scores all four marks.

Question 6 (b)

It was rare to see a fully complete answer scoring four marks. The majority of candidates focused on the reason for the polarity of the water molecule and non-polarity of the carbon dioxide molecule rather than the reason for the polar bonds. Hence, the most common score was 2 marks. Answers relating to 'dipoles cancelling out' were allowed on this occasion but it is worth noting that it is the 'dipole moment' which does or does not cancel out is the correct statement. The dipoles always cancel out because there is a delta plus and a delta minus.

Those candidates that did address the difference in electronegativity as being the reason for the bond polarities, frequently failed to state which element was the more electronegative. It was wondered if this is such an obvious point in the minds of candidates that it was not necessary to state it. Centres and their candidates are reminded that assumptions cannot be made by examiners as to the meaning of a response and explicit statements about the meaning of a response is essential to be confident about gaining credit.



H O H   O=C=O

(b) Explain why both water and carbon dioxide molecules have polar bonds but only water is a polar molecule.

(4)

Both have polar bonds due to ~~being~~ having a simple molecular ~~mole~~ structure and having dipoles such as $H^{\delta+}-O^{\delta-}-H^{\delta+}$ and $O^{\delta-}=C^{\delta+}=O^{\delta-}$. Only water is a polar molecule as the dipoles on CO_2 ~~are~~ cancel each other out and this is due to CO_2 having a symmetrical shape which leads to CO_2 being non-polar.

ResultsPlus
Examiner Comments

This response scores 2 marks.

The first mark is for the polarity of the water and carbon dioxide molecules clearly shown. A second mark here is missed because no electronegativity explanation is provided for these dipoles.

The second mark awarded is for the reference to the symmetry of the carbon dioxide molecule which leads to the dipoles cancelling out. Another mark is missed because there is no clear explanation about the polarity of the water molecule.

(4)

• Hydrogen and oxygen and carbon and oxygen have a large electronegative difference hence the form permanant dipoles which results in polar bond.

• Water is an ~~a ss~~ assymetrical bentshape molecule hence the polar ~~OH~~ O-H bonds do not cancel each other out. hence its a polar molecule.

• Whilst CO_2 is a symmetrical linear shaped ~~molecule~~ molecule in which the polar C=O bonds cancel ~~their po~~ one anothers polarity out hence CO_2 is a non-polar molecule.

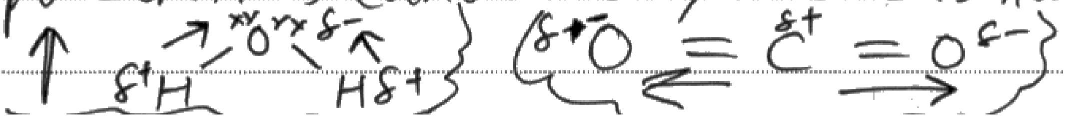
ResultsPlus

Examiner Comments

An example of a response which did refer to the electronegativity difference in the atoms in both molecules but fails to state which is the more electronegative and what polarity results. Hence this aspect of the response gains no credit.

However, two marks are awarded for the statements relevant to both water and carbon dioxide and their molecular polarity or non-polarity.

In water, there is a difference in electronegativity between oxygen & hydrogen (3.5 − 2.1 = 1.4). In CO_2, there is also an electronegativity difference between C & O (3.5 − 2.5 = 1). Therefore, you get a dipole ($H^{\delta+} - O^{\delta-} - H^{\delta+}$ & $O^{\delta-} = C^{\delta+} = O^{\delta-}$). H_2O ~~has a~~ is V-shaped, so there is an overall direction for bond polarities, making water polar. CO_2 is linear, so the bond polarities cancel out, so CO_2 is non-polar.



ResultsPlus
Examiner Comments

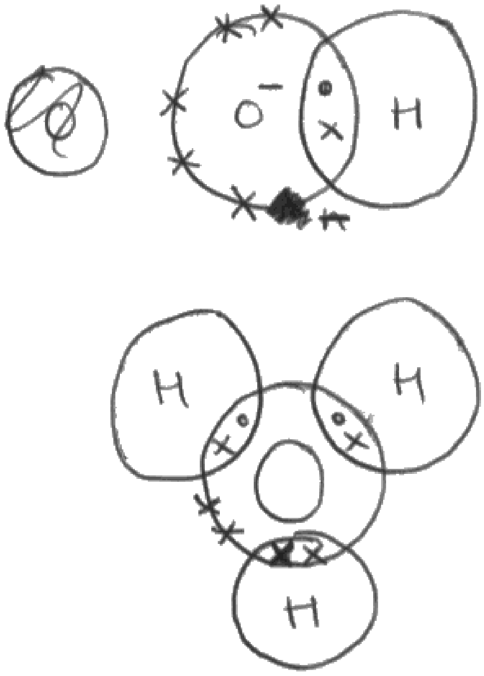
An example of a response which scores all four marks.

Question 6 (c)

The standard of dot and cross diagrams was somewhat disappointing as about two thirds of candidates failed to gain any credit. It was not unusual to see the oxonium ion having an oxygen atom with three bonds to the hydrogen atoms with a dot and a cross, namely that there was no dative covalent bond. The problem with this is that the oxygen then has only five crosses or electrons. Similarly in the hydroxide ion, oxygen was often given with 7 crosses or electrons in order to complete an octet. Candidates appeared to have a disconnect with their knowledge of oxygen being in Group 6 and so having six electrons in its outer energy level or shell and the need for the oxygen atom in the molecule or ion to have eight electrons in the outer shell. More practice would be beneficial.

(c) Pure water ionises to form H_3O^+ and OH^- ions, although only to a very small extent.
Draw the dot-and-cross diagrams of these ions.
Use dots (•) for the hydrogen electrons and crosses (×) for the oxygen electrons.

(2)



ResultsPlus
Examiner Comments

Neither of these diagrams scores a mark.

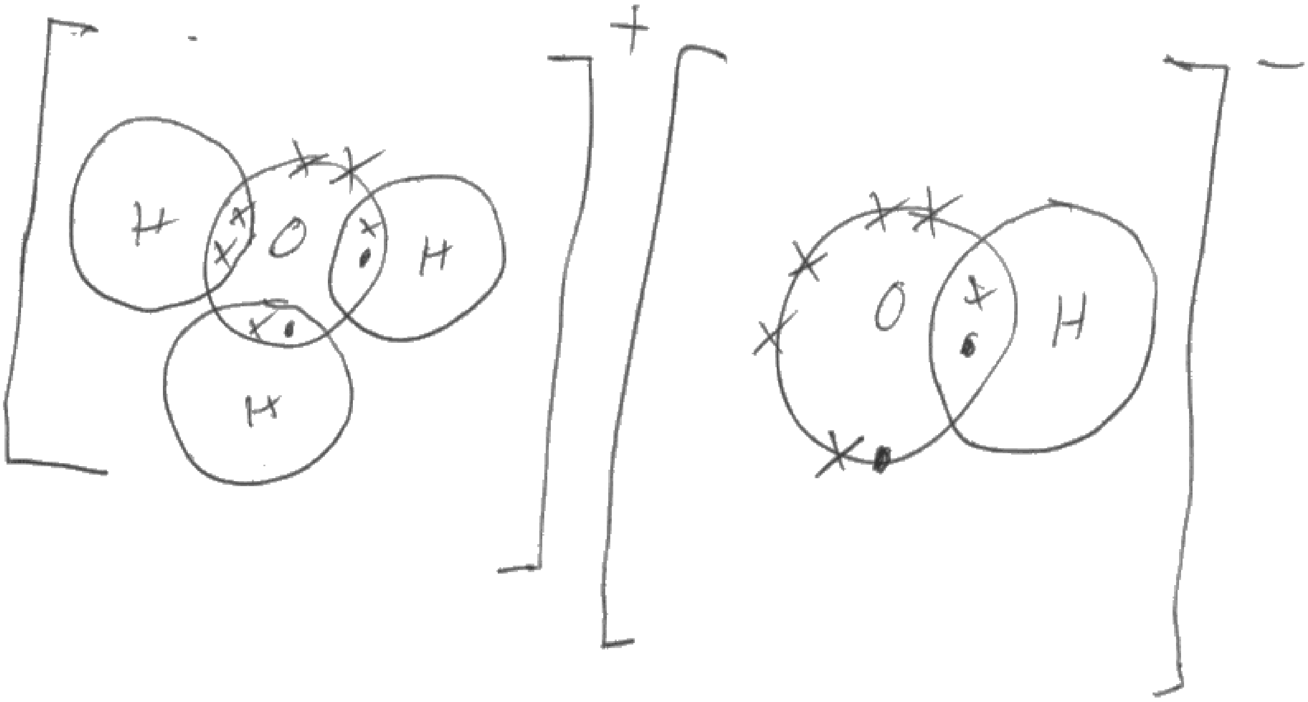
The hydroxide ion diagram has a scribbling out at the bottom and it is unclear whether this is the required additional dot for the electron of the 'lost' hydrogen. It looks more like a negative sign and so no benefit of doubt was given.

The oxonium ion has the correct dots and crosses but is missing the positive charge which means it does not score.

ResultsPlus

Examiner Tip

Double-check all such diagrams for simple missed points that might result in a lost mark.



ResultsPlus

Examiner Comments

An example of a correct response scoring both marks.

Question 6 (d) (i)

A high-scoring question with the vast majority of candidates gaining both marks by correctly calculating the pH of water and giving the answer to the required number of decimal places. A small minority of candidates just used the K_w value to calculate the pH of water and gave an answer of 13.62. This gained no credit and candidates should have realised that such a pH could not possibly be correct for pure water. A useful reminder to centres and candidates that the meaning of the numbers should be kept in mind and will help to discern if the process has been carried out correctly or not.

(d) An equation for the ionisation of water is

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$$

The expression for the ionic product of water is

$$K_w = [H^+(aq)][OH^-(aq)]$$

The value of K_w at 310 K is 2.40×10^{-14} mol^2 dm^{-6}

(i) Calculate the pH of water at 310 K.

Give your answer to **two** decimal places.

(2)

$Kw = [H^+]^2$

$\sqrt{2.40 \times 10^{-14}} = [H^+]$

$[H^+] = 1.549 \times 10^{-7}$

$pH = -\log[1.549 \times 10^{-7}] = 6.8$

ResultsPlus

Examiner Comments

This response scores one mark only because the final answer is not given to two decimal places as required by the question.

$K_w = [H^+]^2 \quad [H^+] = [OH^-]$

$[H^+] = \sqrt{2.4 \times 10^{-14}}$

$= 1.549 \times 10^{-7}$

$pH = -\log 1.549 \times 10^{-7}$

$= 6.81$

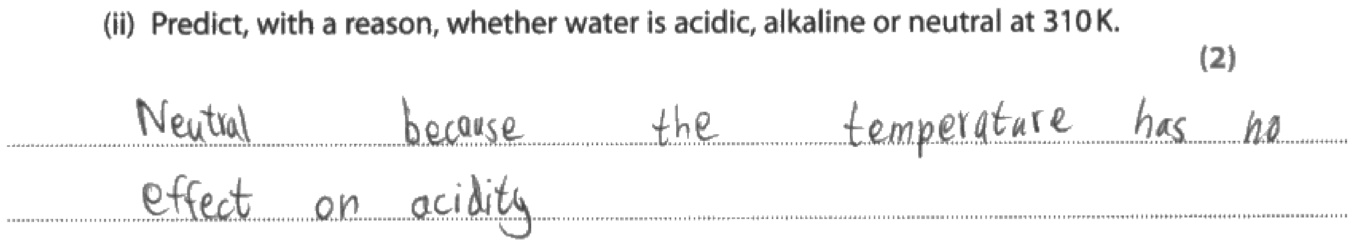
ResultsPlus

Examiner Comments

An example of a response which scores both marks.

Question 6 (d) (ii)

This question highlights the benefits of using the legacy papers for revision as it is a relatively common question but appeared to be novel for candidates on the new specification. The pH scale is temperature dependent and so the neutrality point or value changes with temperature but this seemed beyond the majority of candidates who scored zero. It might have been expected that logic would suggest that water has to be neutral regardless of the temperature but this was not evident to most candidates. Hence, this is an area for centres and candidates to consolidate.



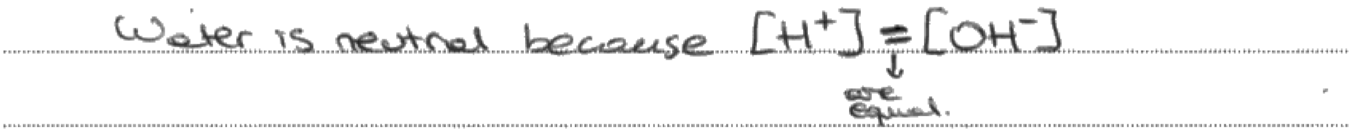
(ii) Predict, with a reason, whether water is acidic, alkaline or neutral at 310 K.

(2)

Neutral because the temperature has no effect on acidity

ResultsPlus
Examiner Comments

This response scores one mark for the reference to the neutrality of water but no reason for why this is the case given. Simply stating that temperature has no effect is not a reason.



Water is neutral because $[H^+] \underset{\downarrow}{=} [OH^-]$

are equal.

ResultsPlus
Examiner Comments

An example of a response which scores both marks.

Question 6 (d) (iii)

An appreciable number of candidates gave a suitable explanation but failed to state the sign of the enthalpy change and so did not gain the mark. A range of acceptable reasons were allowed for the positive sign of the enthalpy change. A small minority of candidates appeared to confuse entropy with enthalpy and so gave answers relating to the increase in the number of moles of products.

(iii) Predict, with a reason, the sign of the enthalpy change for the ionisation of water.

(1)

The enthalpy of ionisation of water is endothermic as when heated ~~equilibrium~~ equilibrium shifts the right.

Examiner Comments

A correct statement but no credit gained because there is no reference made to the sign of the enthalpy change as required in the question.

Positive because as temperature increases value of Kw increases.

Examiner Comments

Excellent answer which scores the mark.

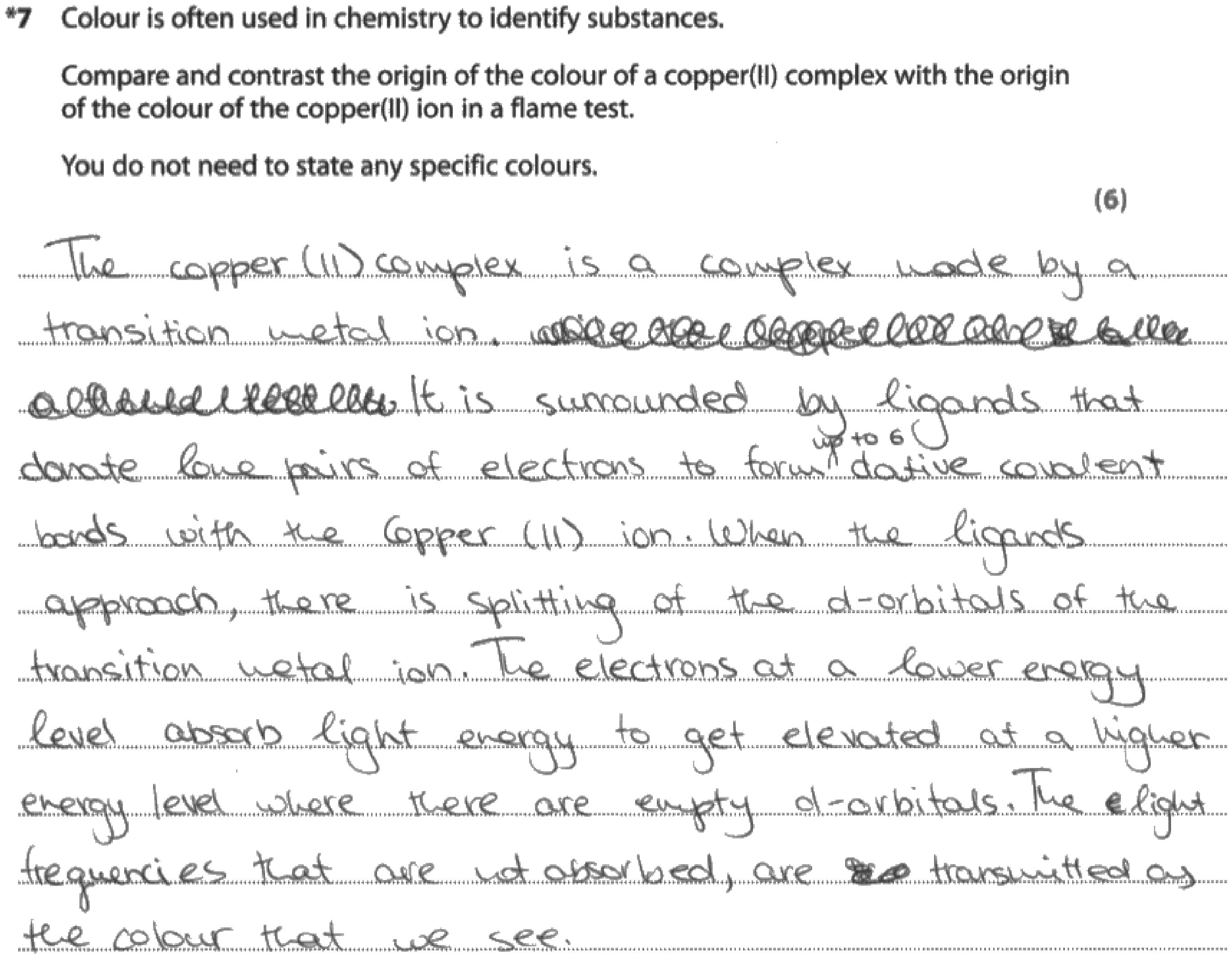
Question 7

This extended response question produced a wide range of marks and was an excellent discriminator, although only a few candidates scored all six marks. The indicative point most frequently lacking was the reference to the difference in energy levels as being the determining factor in the colour observed for both the flame test and of the complex ion. A clear statement was required for both of these discussions.

Since this question is a 'Compare and contrast' type of question it was important for candidates to make sure that there was at least some reference to a comparison of some description between the origin of the two colours. If this was lacking, then one of the structure and reasoning marks was lost.

There was evidence of some confusion in candidates' minds over the origin of colour. For example, the origin of colour for complex ions was at times erroneously attributed to electrons 'falling back' to the lower d orbital or that the emission of light was responsible for the colour observed. These comments illustrate how some candidates had mixed up the origin of the flame test colour with that of origin of complex ion colour.

Another error which was often seen was that of referring to the split of a singular d orbital rather than the splitting of the d orbital subshell.



***7 Colour is often used in chemistry to identify substances.**

Compare and contrast the origin of the colour of a copper(II) complex with the origin of the colour of the copper(II) ion in a flame test.

You do not need to state any specific colours.

(6)

The copper (II) complex is a complex made by a transition metal ion. It is surrounded by ligands that donate lone pairs of electrons to form up to 6 dative covalent bonds with the copper (II) ion. When the ligands approach, there is splitting of the d-orbitals of the transition metal ion. The electrons at a lower energy level absorb light energy to get elevated at a higher energy level where there are empty d-orbitals. The light frequencies that are not absorbed, are transmitted as the colour that we see.

In a flame test however, the process is different. There are electrons as well that absorb energy to move to a higher energy level. But when the ~~metal~~ copper (II) ion is placed near the Bunsen Burner flame during the flame test, the electrons return back to their ground state. They do not remain at the higher energy level like in the copper (II) complexes. Moreover, they emmitt the energy that they have previously absorbed and that is the colour seen during the flame test unlike in copper (II) complexes were the energy released is the one that was not absorbed.

ResultsPlus
Examiner Comments

This response scores 4 marks.

There is no clear reference to the colour being attributed to the difference in the energy levels so no IP1. There is no reference to the heat energy being the reason for the electron promotion in the flame test so no IP2. However, there is correct reference to the return of the electron to the ground state and so IP3 is awarded. The origin of the colour of the complex ion is described correctly for IPs 4-6.

This means that four IPs are awarded which converts to 3 marks. There is a comparison made and so one structure and reasoning mark can also be awarded to give a total of 4 marks.

For copper (II) ions, the electrons absorb heat energy and is promoted to a higher energy level. This is quite unstable, so it falls back down to a lower energy level. The difference in energy is released as a photon and is ~~distinct~~ unique for Cu^{2+}. This photon of a specific wavelength is ~~pere~~ perceived as colour.

For copper (II) complex, the d-subshells split into two different energy levels. As the electron absorbs energy from light, it gets promoted to the higher ~~spli~~ ~~d-subshell~~ d-orbitals. The energy difference is unique so electrons only absorb photons of ~~a~~ certain wavelengths. The lack of these wavelengths cause their complementary colours to take over and become the primary colours perceived.

They are similar in that the colour generated is both through movements of electrons between energy levels. However, colours in flame test for ion ~~are~~ is an emission of photons, while in complex is an absence of photons of specific wavelengths.

ResultsPlus
Examiner Comments

This response scores 5 marks.

The origin of the colour in the flame test and of the complex ion are both correctly described for IPs 2 - 6. There is not sufficient explanation of the colour being due to the difference in the energy levels for both colour origins so no IP1.

The awarding of 5 IPs converts to 3 marks. There is a clear comparison made and so both structure and reasoning marks can be awarded to give a total of 5 marks.

Question 8 (a)

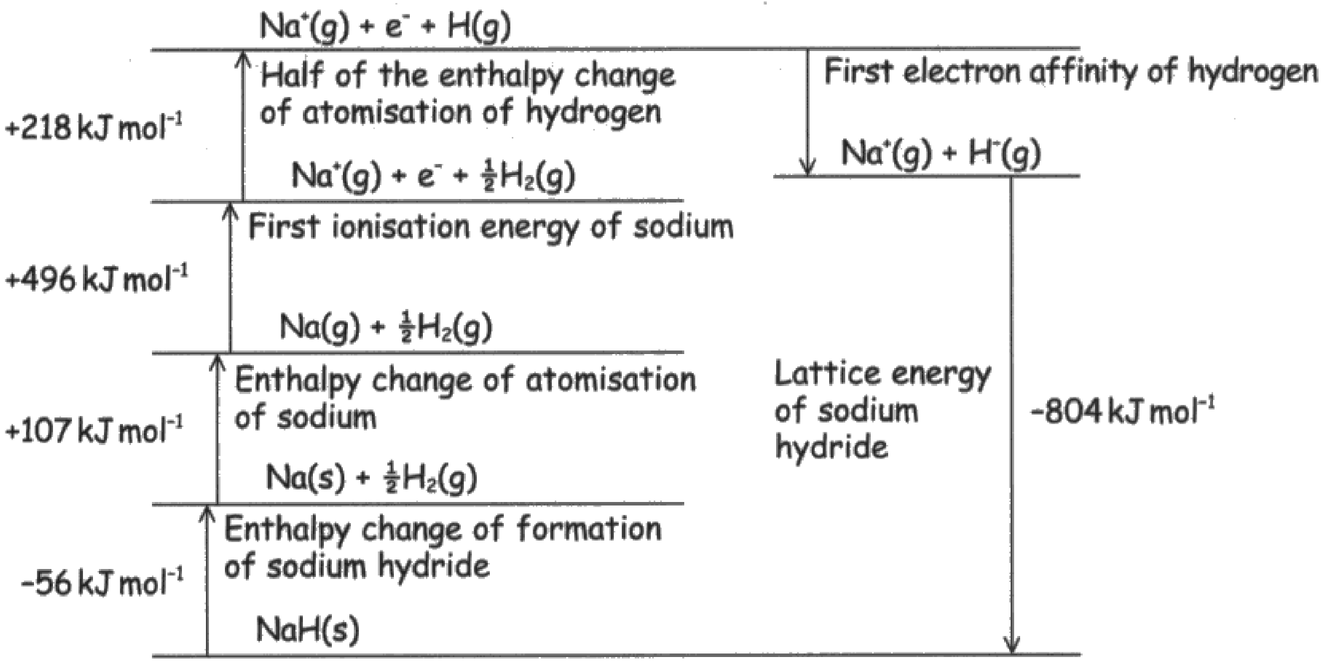
In part (i) only a small minority of candidates scored zero for these questions. The vast majority of candidates correctly identified the error in the diagram of the arrow for the enthalpy change of formation going up when it should be drawn going down. The second error of the 'half' of atomisation was less often identified and serves as a useful reminder to candidates that learning definitions is a very useful exercise as it helps in such situations.

The question introduction stated that the numerical data was correct but some candidates appeared not to have noticed this when they calculated their electron affinity in part (ii) and so obtained an incorrect value. Another useful reminder to candidates to make sure that the introduction to a question often contains vital information to the successful completion of a question.

8 Sodium hydride, NaH, can be used to generate hydrogen for fuel cells.

(a) In order to calculate the first electron affinity of hydrogen, a student was asked to draw a Born-Haber cycle for sodium hydride.

The cycle had **two** errors but the numerical data were correct.



(i) Identify and correct the **two** errors in this Born-Haber cycle.

(2)

The arrow for the enthalpy change of formation of NaH should face downwards

~~The equations for "first ions~~

(ii) Calculate the first electron affinity, in kJ mol^{-1}, of hydrogen, using the values given in the cycle.

(1)

$EA = -218 - 496 - 107 - 56 + 804$

$= \underline{-73 \text{ kJ mol}^{-1}}$

ResultsPlus
Examiner Comments

An example of a response which correctly identified one error for one mark in (i) and carries out the calculation correctly in (ii) for one mark.

(i) Identify and correct the **two** errors in this Born-Haber cycle.

(2)

~~For the energy of atomisation of sodium, it should become~~ ① Enthalpy change of formation of $NaH_{(s)}$ is ~~the~~ pointed in the wrong direction.

② should ~~be~~ not be half, but simply the ~~atomisation~~ enthalpy change of atomisation of hydrogen.

(ii) Calculate the first electron affinity, in kJ mol^{-1}, of hydrogen, using the values given in the cycle.

(1)

-73 kJ mol^{-1}

ResultsPlus

Examiner Comments

An example of a response which scores all available marks.

ResultsPlus

Examiner Tip

Annotations on the diagram are acceptable ways to indicate corrections.

Question 8 (b)

Candidates could calculate the Gibbs Free Energy change in part (i) either by converting both values to Joules or to kilo Joules but it was essential to make one or the other conversion. Some candidates did make this conversion correctly but then gave entropy units instead of enthalpy units which lost them the mark. A reminder to candidates to double-check exactly what value they are calculating. The second mark was awarded for a statement relating to the feasibility of the reaction but there needed to be reference to the reason for this conclusion by stating the sign of the Gibbs Freen Energy change.

Most candidates could successfully calculate the temperature in part (ii) and gave their answers in Kelvin.

(b) The equation for the formation of sodium hydride is

$$Na(s) + \frac{1}{2}H_2(g) \rightarrow NaH(s) \qquad \Delta_f H^{\circ} = -56\,kJ\,mol^{-1}$$

The standard entropy change of the system, $\Delta S^{\circ}_{system}$, for this reaction is $-76.5\,J\,K^{-1}\,mol^{-1}$.

(i) Deduce the feasibility of this reaction at 298 K by calculating the free energy change, ΔG.

(2)

$\Delta G = \Delta H - T\Delta S_{system}$

$= -56000 - 298(-76.5)$

$= -33203\ kJ\,mol^{-1}$

As the value is ~~[illegible]~~ ~~-ve~~ negative, the reaction is feasible.

(ii) Calculate the temperature at which $\Delta G = 0$.

(1)

$0 = -56000 - T(-76.5)$

$56000 = -T(-76.5)$

$732.03K = T$

$732K = T$

ResultsPlus
Examiner Comments

In part (i) the calculation has been carried out correctly but unfortunately the stated units are incorrect so only one mark was awarded. The correct comment on the negative value of Gibbs Free Energy was given credit.

In part (ii) the calculation is correct for the mark.

(i) Deduce the feasibility of this reaction at 298 K by calculating the free energy change, ΔG.

(2)

$\Delta G = T \Delta S$

$\frac{76.5}{1000} = 0.0765$

~~$\Delta G = 298 \times 76.5$~~

$\Delta G = 298 \times 0.0765$

$\Delta G = -22.797$

This reaction is not feasible

(ii) Calculate the temperature at which ΔG = 0.

(1)

~~$0 =$~~

$T =$ ~~$\frac{\Delta G}{\Delta S}$~~

$0 = T + 0.0765$

$\frac{0}{0.0765} = 0$

$T = 0$

ResultsPlus

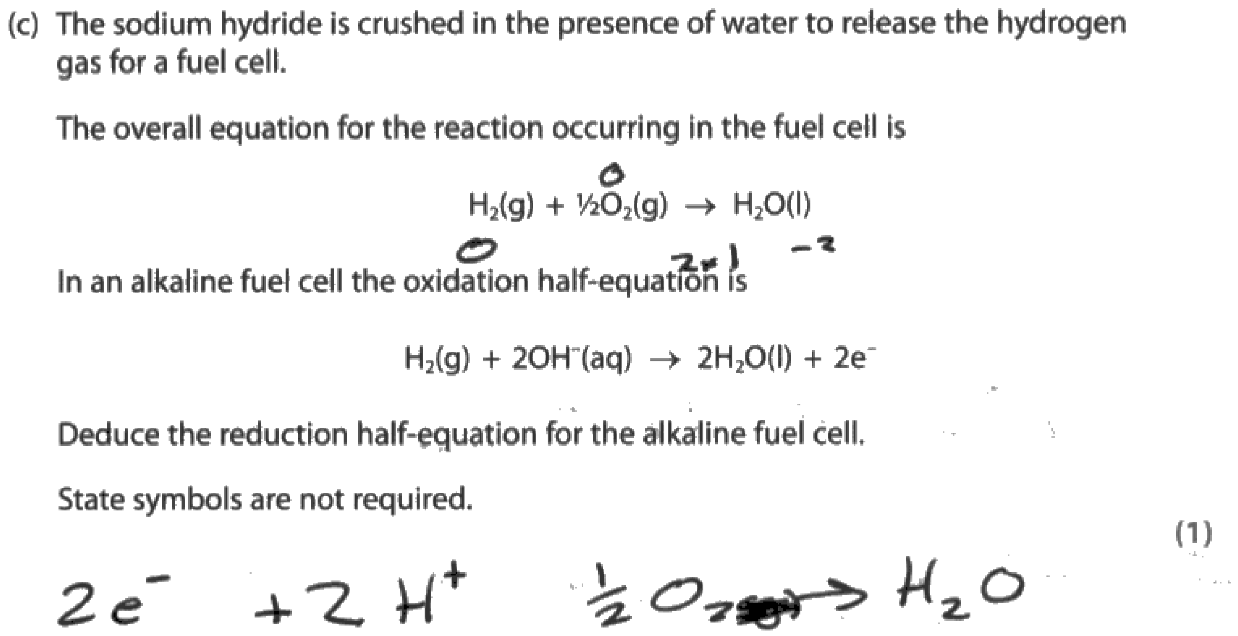
Examiner Comments

This response does not score any marks.

The calculation in part (i) is incorrect but transferred error could have been applied for the second mark. In this example, the statement is incorrect as a negative value indicates that it is feasible and there is no reference to the sign of the change.

Question 8 (c)

Only about a third of candidates successfully answered this question. A significant number of candidates gave the acidic half equation but the alkaline fuel cell was the subject of the question and so this did not score. Once again, a reminder to make sure that the answer given does match the question set.



(c) The sodium hydride is crushed in the presence of water to release the hydrogen gas for a fuel cell.

The overall equation for the reaction occurring in the fuel cell is

$$H_2(g) + \tfrac{1}{2}\overset{0}{O}_2(g) \rightarrow H_2O(l)$$

0 2×1 −2

In an alkaline fuel cell the oxidation half-equation is

$$H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-$$

Deduce the reduction half-equation for the alkaline fuel cell.

State symbols are not required.

(1)

$$2e^- \quad + 2H^+ \quad \tfrac{1}{2}O_2 \rightarrow H_2O$$

ResultsPlus
Examiner Comments

Although this is a balanced half equation, it is not the one for the alkaline fuel cell and so does not score.

ResultsPlus
Examiner Tip

Make sure that the answer given is the one needed for the question set.

Deduce the reduction half-equation for the alkaline fuel cell.

State symbols are not required.

(1)

$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

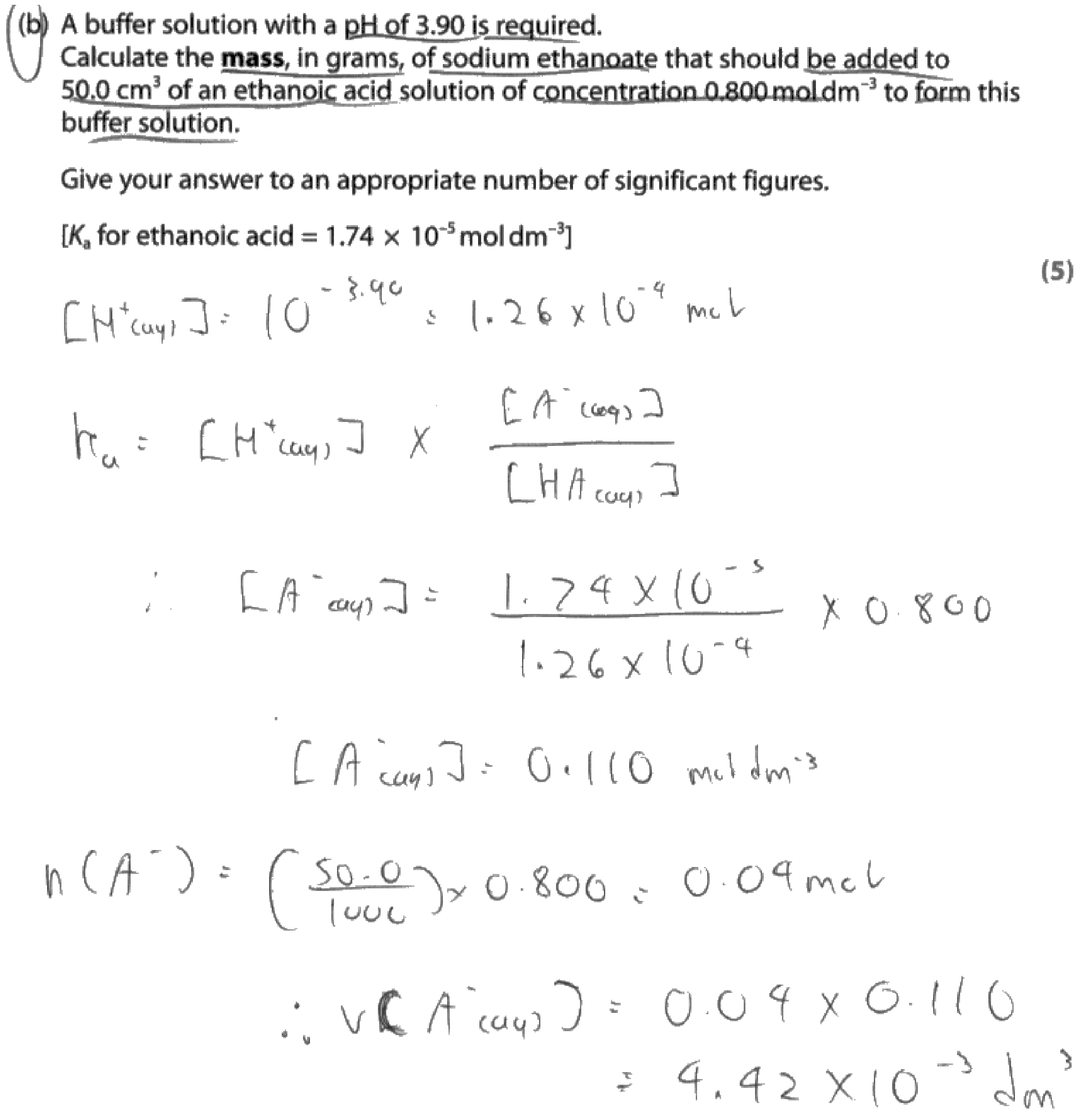
ResultsPlus

Examiner Comments

A good example of a multiple equation which scored the mark.

Question 9 (b)

A full spread of marks was seen, with the most common score being full marks. Nonetheless, buffer calculations would prove to be a worthwhile area for practice. The advice to candidates on any calculation is to make sure that each step of the calculation is clearly laid out. Transferred errors are often applied throughout the calculation so candidates are encouraged to continue their attempt even if they are unsure of a particular step.



(b) A buffer solution with a pH of 3.90 is required.
Calculate the **mass**, in grams, of sodium ethanoate that should be added to 50.0 cm^3 of an ethanoic acid solution of concentration 0.800 mol dm^{-3} to form this buffer solution.

Give your answer to an appropriate number of significant figures.

[K_a for ethanoic acid = 1.74×10^{-5} mol dm^{-3}]

(5)

$[H^+_{(aq)}] = 10^{-3.90} = 1.26 \times 10^{-4}$ mol

$$K_a = [H^+_{(aq)}] \times \frac{[A^-_{(aq)}]}{[HA_{(aq)}]}$$

$$\therefore [A^-_{(aq)}] = \frac{1.74 \times 10^{-5}}{1.26 \times 10^{-4}} \times 0.800$$

$[A^-_{(aq)}] = 0.110$ mol dm^{-3}

$n(A^-) = \left(\frac{50.0}{1000}\right) \times 0.800 = 0.04$ mol

$\therefore V[A^-_{(aq)}] = 0.04 \times 0.110$

$= 4.42 \times 10^{-3}$ dm^3

ResultsPlus
Examiner Comments

This response scores two marks.

One mark is awarded for the calculation of hydrogen ion concentration from pH. A second mark is awarded for the rearrangement and calculation of the sodium ethanoate concentration.

The following multiplication by 50/1000 is of the wrong value and so does not score. No conversion of moles to mass is made so no further credit is given.

$pH = 3.90$

$\therefore [H^+] = 10^{-3.9} = 1.2589 \times 10^{-4}$

$$Ka = \frac{[CH_3COO^-Na^+][H^+]}{[CH_3COOH]}$$

$$1.74 \times 10^{-5} = \frac{[x][1.2589 \times 10^{-4}]}{[0.8]}$$

$x = 0.1105704903$

$n = \frac{v \times c}{1000} = \frac{50 \times (\text{[illegible]})}{1000} = 5.5285 \times 10^{-3}$

$m = mr \times n$

$= 82 \times 5.5285 \times 10^{-3}$

$= \underline{0.453g} \rightarrow \triangleright$

ResultsPlus
Examiner Comments

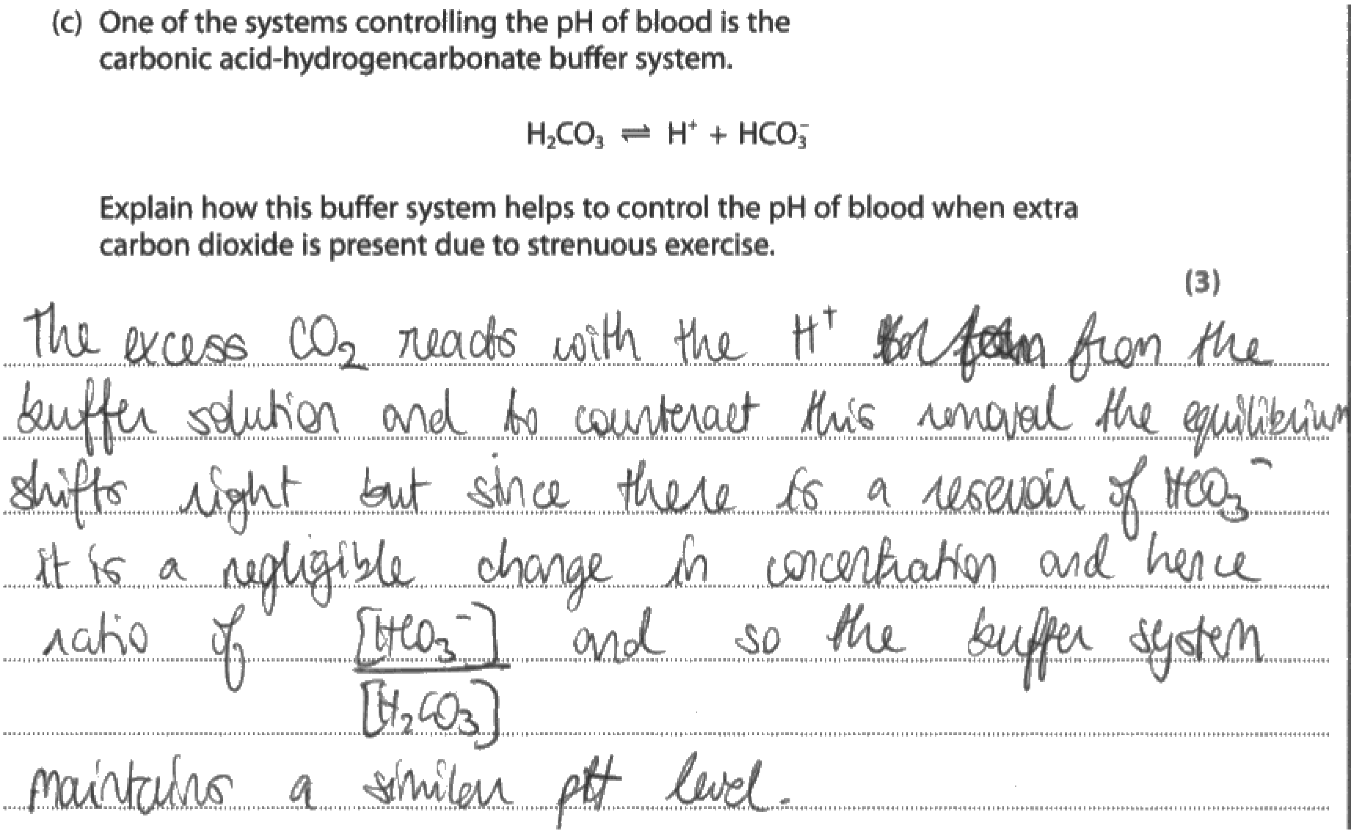
An example of a response which calculated the correct answer and scored all five marks.

Question 9 (c)

The answers to this question were the most disappointing on the paper. The majority of responses had several lines of prose but which contained a wide range of chemical errors. It was particularly important for the whole response to be read in its entirety before any credit was given. One example of a common error was the formation of carbonic acid by carbon dioxide but not from the reaction with water but rather from a 'supposed' reaction with hydrogen ions. Another common error seen starts correctly by referring to the shifting of the equilibrium to the right, but then states that this movement is due to the reaction of carbon dioxide with hydrogen ions and it is this reaction which is given as justification.

A number of candidates correctly stated that the position of equilibrium shifted to the right but failed to accompany the statement with the effect of an increase in hydrogen ions.

Clearly this topic area is one which centres and candidates would benefit from revision and consolidation.



(c) One of the systems controlling the pH of blood is the carbonic acid-hydrogencarbonate buffer system.

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

Explain how this buffer system helps to control the pH of blood when extra carbon dioxide is present due to strenuous exercise.

(3)

The excess CO_2 reacts with the H^+ ~~to form~~ from the buffer solution and to counteract this removal the equilibrium shifts right but since there is a reservoir of HCO_3^- it is a negligible change in concentration and hence ratio of $\frac{[HCO_3^-]}{[H_2CO_3]}$ and so the buffer system maintains a similar pH level.

ResultsPlus
Examiner Comments

This response is an example of one where an incorrect statement is made. Carbon dioxide does not react with hydrogen ions but rather reacts with water to make carbonic acid which then dissociates to give hydrogen ions.

A correct comment is made about the reservoir of hydrogen carbonate ions but does not score because there is no mention of their role in the process.

This means that this response scores zero.

carbon dioxide can lower the PH in the blood if it forms carbonic acid which would turn blood Acidic! To prevent this from happening carbonic acid-hydrogencarbonate acts as a buffer (keeps the PH constant if small amounts of acid or base is added) which in this case is CO_2. It buffers and keeps the PH of blood normal so all body processes can continue normally by conteracting any PH changes CO_2 makes.

ResultsPlus
Examiner Comments

This response scores one mark for the statement about the formation of carbonic acid. The subsequent comments are simply general statements about buffers and not applied to the specific example of the question, hence no credit was given.

Question 9 (d)

In part (i) it was evident that candidates would benefit from further practice at drawing titration curves and also need to be reminded of the need for precision/accuracy with the drawing of such curves. The mark scheme gave clear guidance of the parameters required for each marking point and these do result in a strictness which some candidates may not fully appreciate. One example is that for a strong base titration the pH should reach the required pH within 10 cm^3 of the vertical part of the curve. Another example is that the curve had to be drawn from zero and finish at 100 cm^3. Some candidates did not complete their curve to the end of the graph paper and so lost one mark.

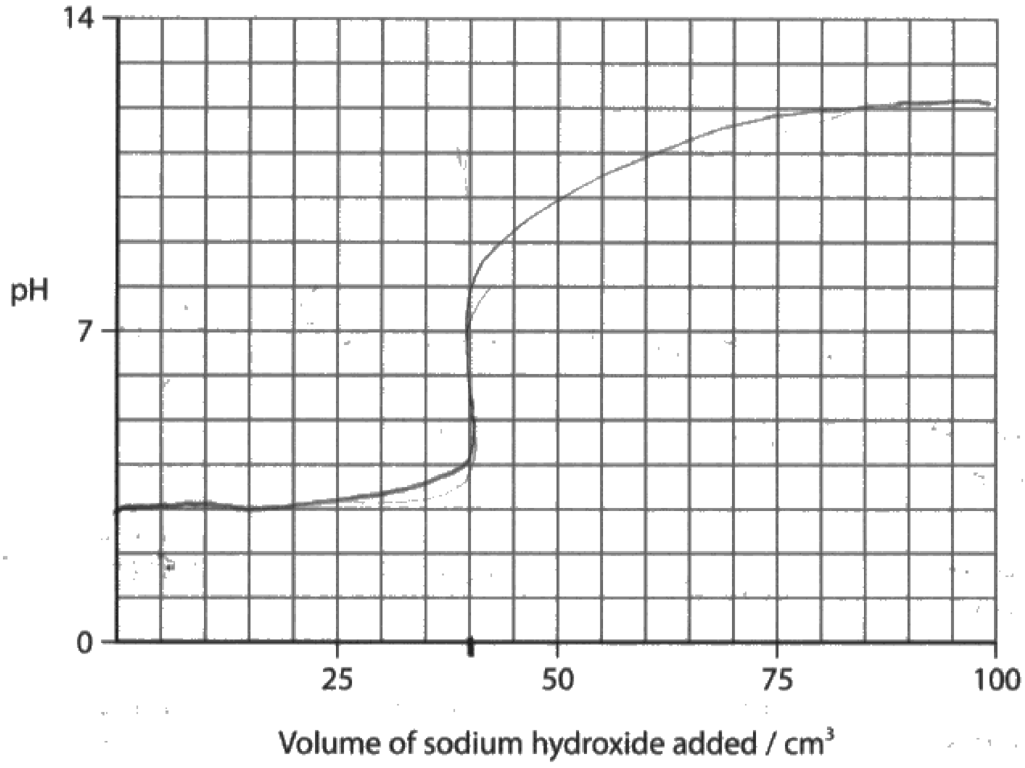
The answers given to part (ii) were frequently of a very high standard and it was apparent that candidates had clearly rehearsed answering this type of question. This is excellent and full marks were often awarded.

(d) A weak acid-strong base titration curve can be used to demonstrate buffer action.

(i) Draw a titration curve for the addition of
100 cm^3 of sodium hydroxide solution of concentration 0.100 mol dm^{-3} to
40.0 cm^3 of propanoic acid solution of concentration 0.100 mol dm^{-3}
which has a pH of 3.0.

Show the part of the curve that demonstrates buffer action.

(4)



(ii) Describe, without calculation, how you would use your curve to determine the value of K_a for propanoic acid.

(2)

You would look at the pH at 20cm^3 which is the half equivalence point (half the acid has been neutralised) at this point which gives you the pka. The pH at this point is the pka. To work out ka you should do ka = 10^{-pka} giving you ~~pka~~ ka.

ResultsPlus

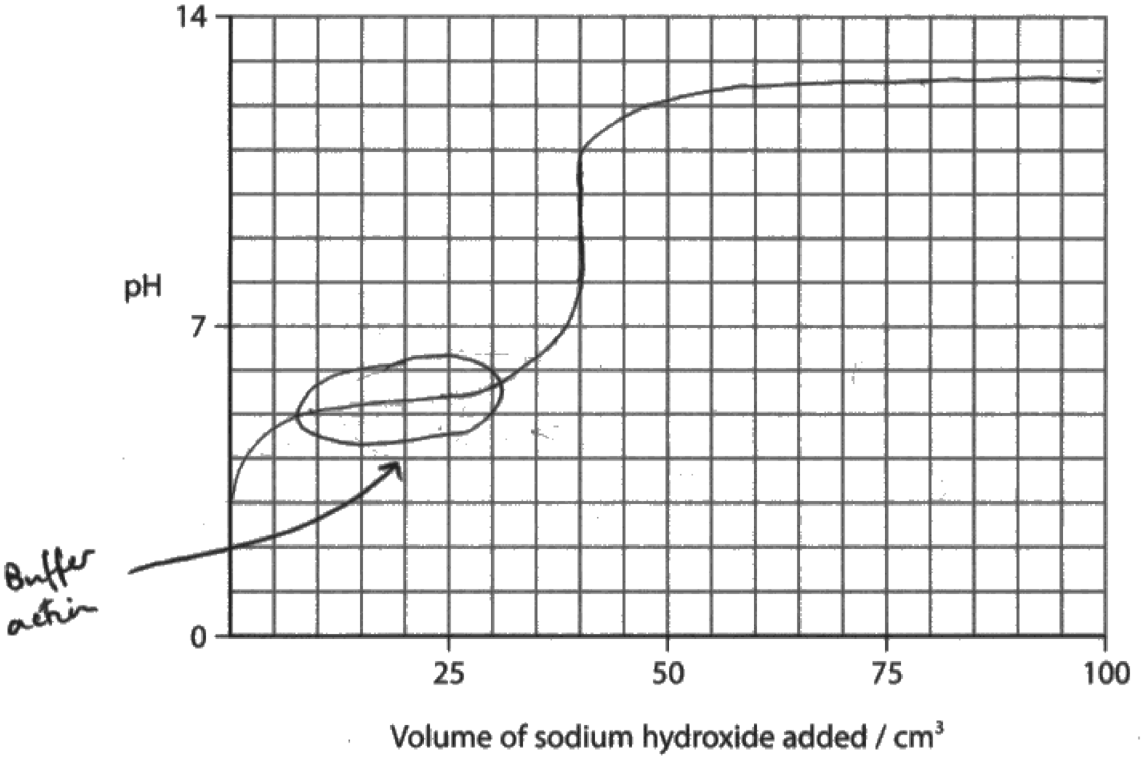
Examiner Comments

In part (i) the sketch scores two marks. The general shape is not that of a weak acid-strong base titration. The curve does not reach pH~12-13 by about 10 cm^3 after the vertical section so no marking point 1. The sketch does start and end at the correct values so marking point 2 is awarded. The vertical part of the curve is also at the correct place and so scores marking point 3. There is no label of the buffer action so marking point 4 is not awarded.

Part (ii) is correct and scores both marks.

Show the part of the curve that demonstrates buffer action.

(4)



(ii) Describe, without calculation, how you would use your curve to determine the value of K_a for propanoic acid.

(2)

· Determine the pH at the half equivalence point

(20cm³) at half equivalence point

· $pH = pKa$ ∴ $Ka = 10^{-pH}$

· $Ka = \frac{[H^+]\cancel{[CH_3CH_2COO^-]}}{\cancel{[CH_3CH_2COOH]}}$

(Total for Question 9 = 15 marks)

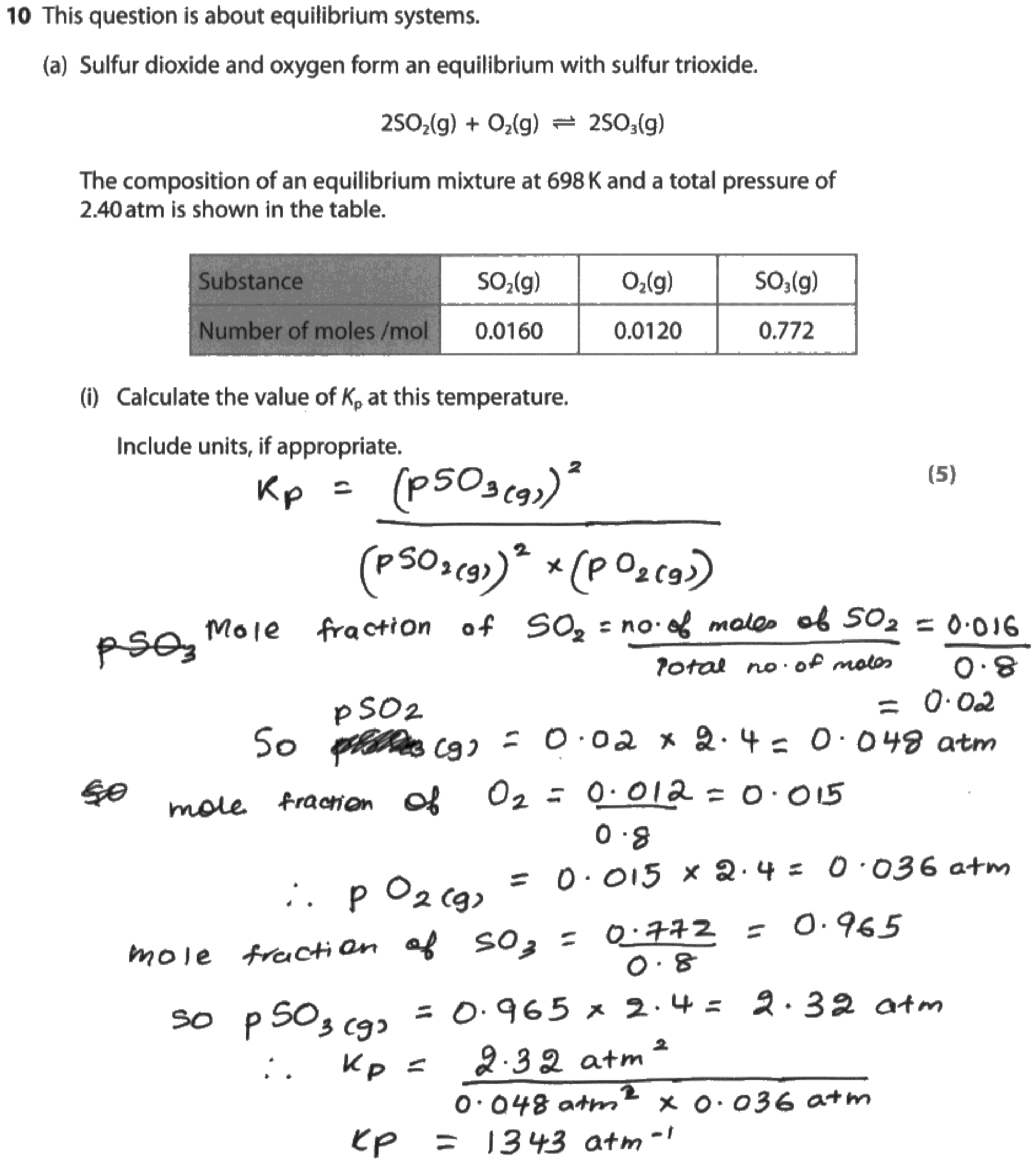
$-\log_{10}(H^+) = -\log_{10} Ka$

ResultsPlus
Examiner Comments

An example of a correct response which scores full marks.

Question 10 (a) (i)

Candidates clearly have been practicing this type of calculation as just under half of all responses scored full marks. Revision had paid off. When errors were seen it was often a case of candidates using moles directly to calculate partial pressures rather than mole fractions. Occasionally candidates were rather careless with their transfer of numbers and inserted or omitted a zero which resulted in an incorrect final value. A reminder to always double-check working.



10 This question is about equilibrium systems.

(a) Sulfur dioxide and oxygen form an equilibrium with sulfur trioxide.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The composition of an equilibrium mixture at 698 K and a total pressure of 2.40 atm is shown in the table.

Substance	SO_2(g)	O_2(g)	SO_3(g)
Number of moles /mol	0.0160	0.0120	0.772

(i) Calculate the value of K_p at this temperature.

Include units, if appropriate.

(5)

$$K_p = \frac{(pSO_{3(g)})^2}{(pSO_{2(g)})^2 \times (pO_{2(g)})}$$

~~pSO_3~~ Mole fraction of SO_2 = $\frac{\text{no. of moles of } SO_2}{\text{Total no. of moles}} = \frac{0.016}{0.8}$

$= 0.02$

So pSO_2 ~~[illegible]~~ (g) = 0.02 × 2.4 = 0.048 atm

~~[illegible]~~ mole fraction of O_2 = $\frac{0.012}{0.8}$ = 0.015

∴ $pO_{2(g)}$ = 0.015 × 2.4 = 0.036 atm

mole fraction of SO_3 = $\frac{0.772}{0.8}$ = 0.965

so $pSO_{3(g)}$ = 0.965 × 2.4 = 2.32 atm

∴ $K_p = \frac{2.32 \text{ atm}^2}{0.048 \text{ atm}^2 \times 0.036 \text{ atm}}$

K_p = 1343 atm^{-1}

ResultsPlus
Examiner Comments

This response scores 4 marks.

The working is all correct up to the final step. The expression and values for K_p are correct but the numbers have been used incorrectly and so the wrong value obtained. Hence just one mark is lost.

ResultsPlus
Examiner Tip

Always double-check calculations to ensure that errors are spotted and corrected.

(i) Calculate the value of K_p at this temperature.

Include units, if appropriate.

(5)

$$K_p = \frac{p(SO_3)^2}{p(SO_2)^2 p(O_2)}$$

SO_2 $\frac{1}{50} \times 2.4$ O_2 $\frac{3}{200} \times 2.4$ SO_3 $\frac{193}{200} \times 2.4$

$$\frac{atm\ atm}{atm\ atm\ atm}$$

$$K_p = \frac{\left(\frac{529}{250}\right)^2}{\left(\frac{6}{125}\right)^2 \times \left(\frac{9}{250}\right)}$$

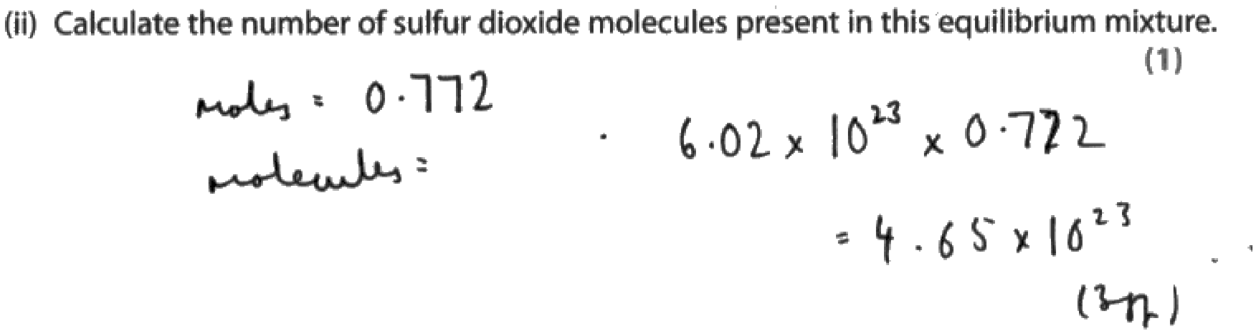
$$K_p = 6.47 \times 10^4\ atm^{-1}$$

ResultsPlus
Examiner Comments

An example of a response which correctly calculates the value of K_p and scores full marks.

Question 10 (a) (ii)

This calculation of the number of molecules using the Avogadro constant produced nearly a 50:50 split over those who could do this type of sum and those who couldn't. This was a bit surprising. It is possible that this is a reflection of other molar calculations being given lots of practice but this type of calculation using the Avogadro constant maybe receiving much less practice. Hence centres and their candidates would benefit from more practice in this area.



(ii) Calculate the number of sulfur dioxide molecules present in this equilibrium mixture.

(1)

moles = 0.772

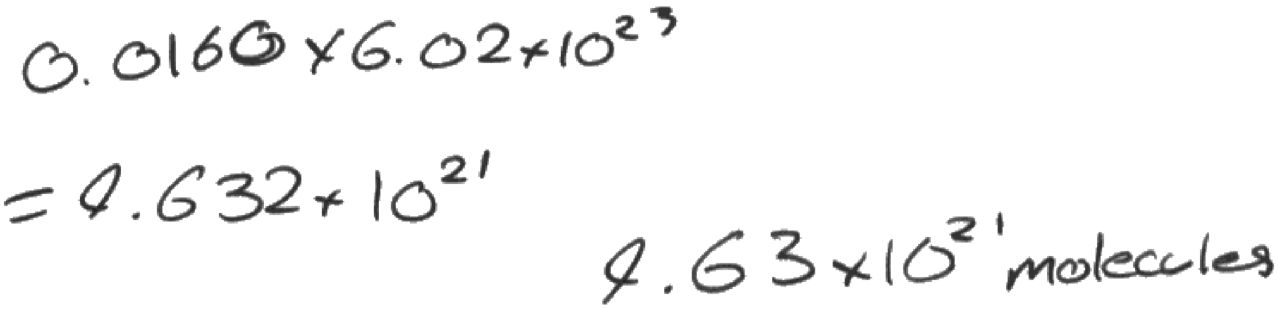
molecules = $6.02 \times 10^{23} \times 0.772$

$= 4.65 \times 10^{23}$

(3sf)

ResultsPlus
Examiner Comments

An example of a response which uses an incorrect number of moles in the calculation and so does not score.



$0.0160 \times 6.02 \times 10^{23}$

$= 9.632 \times 10^{21}$

9.63×10^{21} molecules

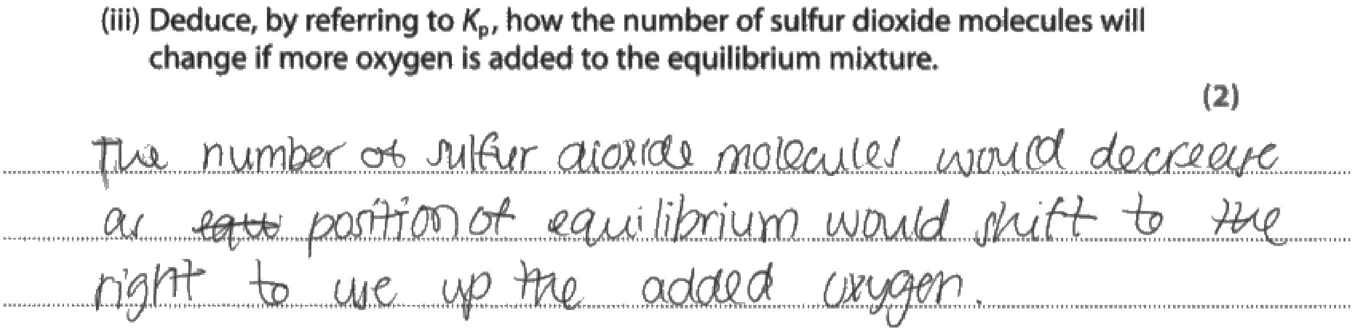
ResultsPlus
Examiner Comments

An example of a correct response.

Question 10 (a) (iii)

This question was worth two marks and two points were required from careful reading of the question. It was noteworthy that a large number of candidates addressed their answer to one or other of these points but rarely both. This emphasises the need to read the question again to ensure that all parts are being addressed.

The question required a statement about what happened to the number of sulfur dioxide molecules and why for one mark, and also to include a reference to the value of K_p. It was rather surprising the significant number of candidates who referred to K_p changing, whereas temperature is the only factor that changes K_p. This is a topic area which would benefit from renewed emphasis by centres and their candidates.



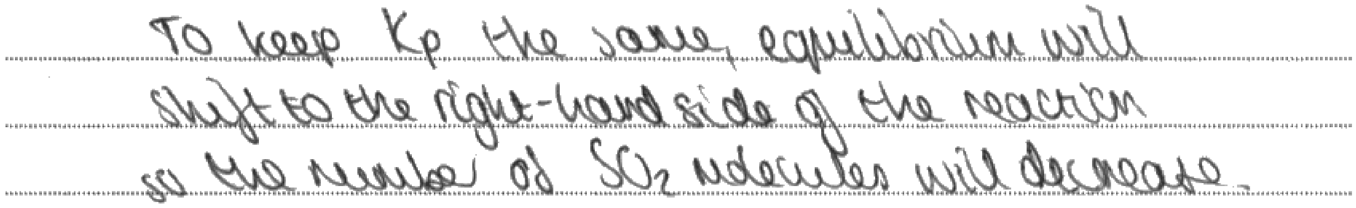
(iii) Deduce, by referring to K_p, how the number of sulfur dioxide molecules will change if more oxygen is added to the equilibrium mixture.

(2)

The number of sulfur dioxide molecules would decrease as ~~equ~~ position of equilibrium would shift to the right to use up the added oxygen.

ResultsPlus
Examiner Comments

An example of a response which scores one mark only. Note that there is no reference to K_p despite this clearly being stated in the question. The mark is gained for the description of the decrease in sulfur dioxide molecules because of the shift in the equilibrium to the right.



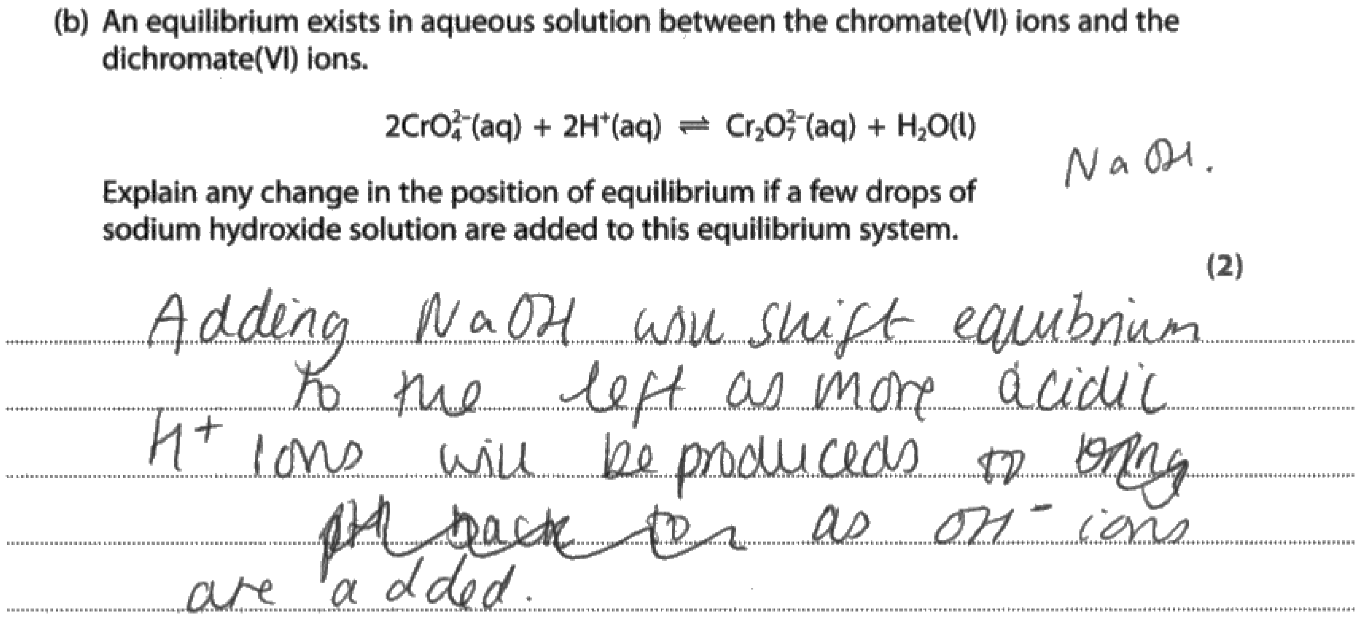
To keep Kp the same, equilibrium will shift to the right-hand side of the reaction so the number of SO_2 molecules will decrease.

ResultsPlus
Examiner Comments

An example of a response which scores both marks. The statement is made that the value of K_p is kept the same and that the equilibrium shifts to the right which results in the number of sulfur dioxide molecules decreasing.

Question 10 (b)

For the most part this question was answered well. Only a minority of candidates stated that the equilibrium shifted to the right which scored zero. Most candidates understood that the equilibrium position moved to the left but often simply stated that the hydroxide ions react with the hydrogen ions without referring to a decrease in concentration of the hydrogen ions or the formation of water which meant that no second mark was awarded. A small number of candidates mentioned a colour change due to the change in concentration of dichromate/chromate ions but this was irrelevant to the question set and gained no credit.



(b) An equilibrium exists in aqueous solution between the chromate(VI) ions and the dichromate(VI) ions.

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$$

Explain any change in the position of equilibrium if a few drops of sodium hydroxide solution are added to this equilibrium system.

NaOH.

(2)

Adding NaOH will shift equilibrium to the left as more acidic H^+ ions will be produceds to bring pH back to as OH^- ions are added.

ResultsPlus

Examiner Comments

One mark scored for the correct movement of the position of equilibrium but no second mark because there is no explanation for what the hydroxide ions are actually doing. In this instance the equilibrium shifts left because the hydroxide ions combine with hydrogen ions to make water. This reduction in concentration of the hydrogen ions results in the movement of the equilibrium position.

ResultsPlus

Examiner Tip

In an explain-type question there needs to be a reason given for the effect or action.

Paper Summary

Based on the performance on this paper, students should:

- Become more familiar with and use correctly the appropriate chemical terms
- Practice balancing equations, both for atoms and charge
- Note that the higher demand of A Level can mean that two facets or parts of an answer can be required for just one mark
- Double-check all calculations to ensure that no transfer errors or similar have been made
- Read questions again so that extra care has been taken to address all aspects of the question that is required
- Use the legacy exam papers for additional practice.

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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