Examiners' Report
June 2014

GCE Chemistry 6CH04 01

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June 2014

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Introduction

The paper seemed fully accessible to all abilities of candidates. It seemed demanding to a few candidates as they were often placed in less familiar situations in calculations and explanations. However, overall their performance was still good giving the paper quite a high mean mark, with a reasonable standard deviation.

There was no evidence of any candidate being short of time to finish the paper.

Question 9 (a-c)

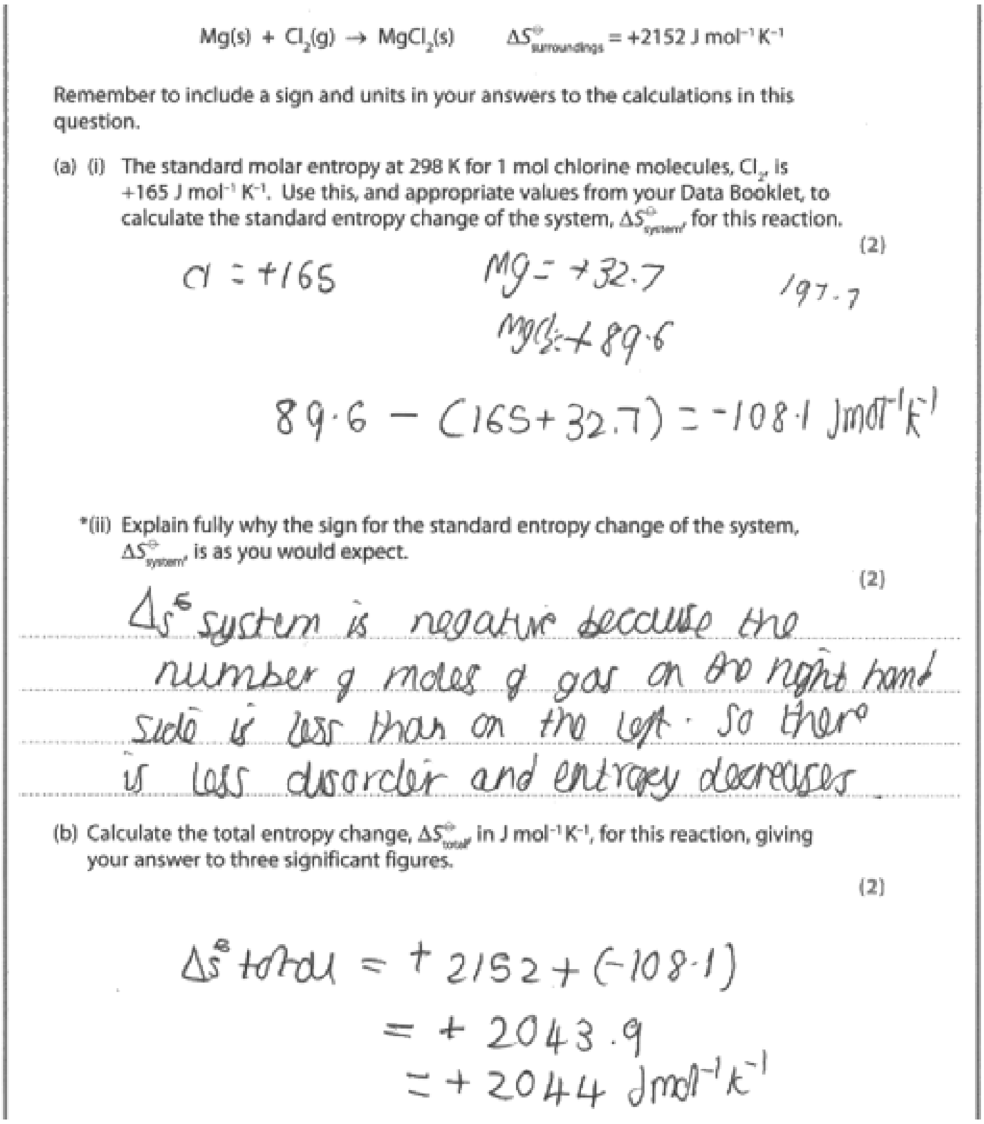
This was a fairly straightforward section of entropy calculations and questions. As usual care was needed in looking up data and execution of the calculations.

In part (i) common errors were the wrong data for the entropy of magnesium chloride or magnesium, and choosing the wrong column or the wrong row. A ruler is helpful to avoid this.

In part (ii) there was the usual confusion between moles and molecules. For example 'Two molecules go to one molecule'

In (b) many answers were given to four or five significant figures.

In (c) the sign was often lost. More serious were the candidates who confused total entropy with entropy of surroundings.



$Mg(s) + Cl_2(g) \rightarrow MgCl_2(s)$ $\Delta S^{\ominus}_{surroundings} = +2152\ J\ mol^{-1}\ K^{-1}$

Remember to include a sign and units in your answers to the calculations in this question.

(a) (i) The standard molar entropy at 298 K for 1 mol chlorine molecules, Cl_2, is +165 J mol^{-1} K^{-1}. Use this, and appropriate values from your Data Booklet, to calculate the standard entropy change of the system, $\Delta S^{\ominus}_{system}$, for this reaction.

(2)

Cl = +165 Mg = +32.7 197.7

$MgCl_2$ = +89.6

89.6 − (165+32.7) = −108.1 Jmol^{-1}K^{-1}

*(ii) Explain fully why the sign for the standard entropy change of the system, $\Delta S^{\ominus}_{system}$, is as you would expect.

(2)

ΔS° system is negative because the number of moles of gas on the right hand side is less than on the left. So there is less disorder and entropy decreases

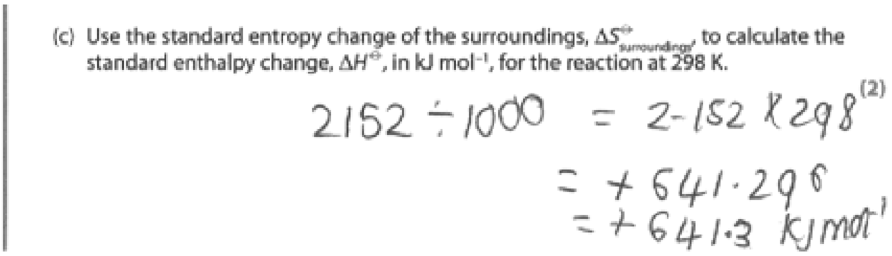
(b) Calculate the total entropy change, $\Delta S^{\ominus}_{total}$, in J mol^{-1} K^{-1}, for this reaction, giving your answer to three significant figures.

(2)

ΔS° total = +2152 + (−108.1)

= +2043.9

= +2044 Jmol^{-1}K^{-1}



(c) Use the standard entropy change of the surroundings, $\Delta S^{\ominus}_{surroundings}$, to calculate the standard enthalpy change, $\Delta H^{\ominus}$, in kJ mol^{-1}, for the reaction at 298 K.

(2)

2152 ÷ 1000 = 2.152 × 298

= +641.296

= +641.3 kJmol^{-1}

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Examiner Comments

(a)(i) Is fine.

(ii) This is a reasonable alternative to gas going to solid, so worth 1 mark.

(b) The value is correct but given to 4 SF, worth 1 mark.

(c) The value is correct but the sign is wrong.

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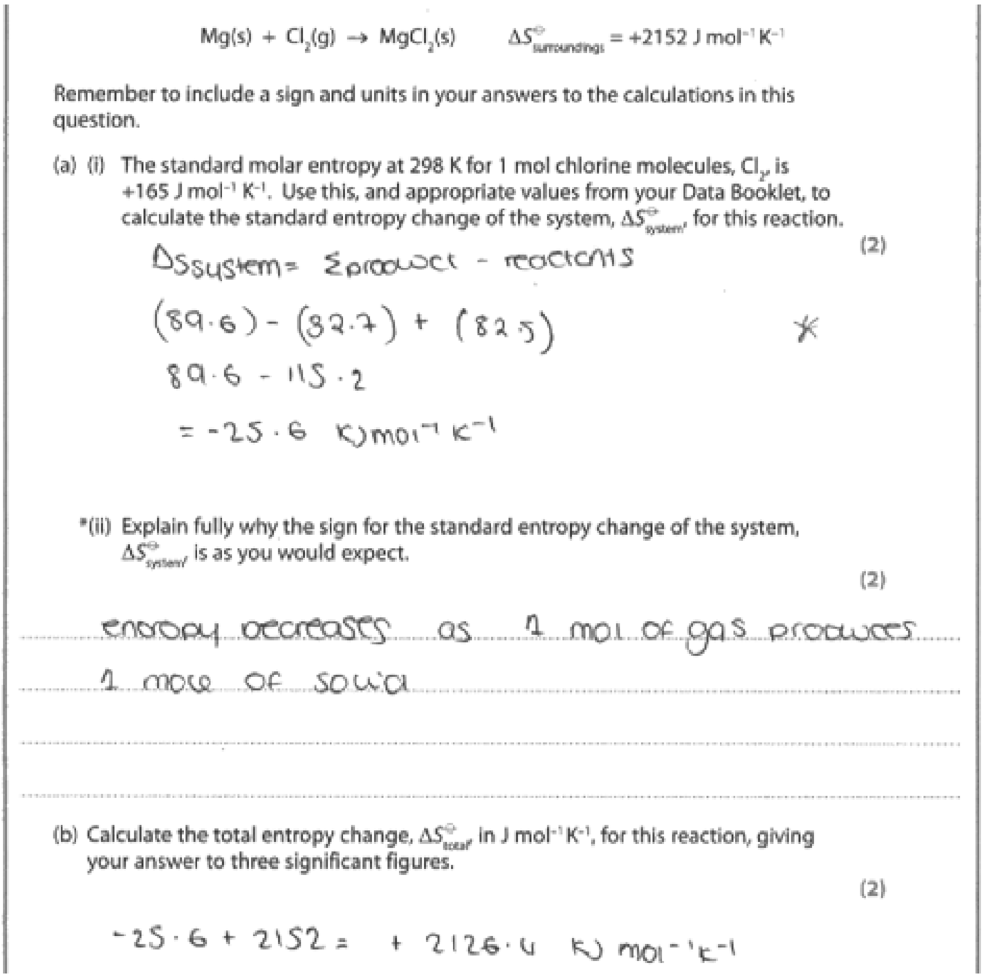
Examiner Tip

It is important to read the question carefully, even in straight forward calculations. (Read the question twice - RTQ^2)



$Mg(s) + Cl_2(g) \rightarrow MgCl_2(s) \qquad \Delta S^{\ominus}_{surroundings} = +2152\ J\ mol^{-1}\ K^{-1}$

Remember to include a sign and units in your answers to the calculations in this question.

(a) (i) The standard molar entropy at 298 K for 1 mol chlorine molecules, Cl_2, is $+165\ J\ mol^{-1}\ K^{-1}$. Use this, and appropriate values from your Data Booklet, to calculate the standard entropy change of the system, $\Delta S^{\ominus}_{system}$, for this reaction.

(2)

$\Delta S_{system} = \Sigma$ product - reactions

(89.6) - (32.7) + (82.5) *

89.6 - 115.2

= -25.6 KJ mol^{-1} K^{-1}

*(ii) Explain fully why the sign for the standard entropy change of the system, $\Delta S^{\ominus}_{system}$, is as you would expect.

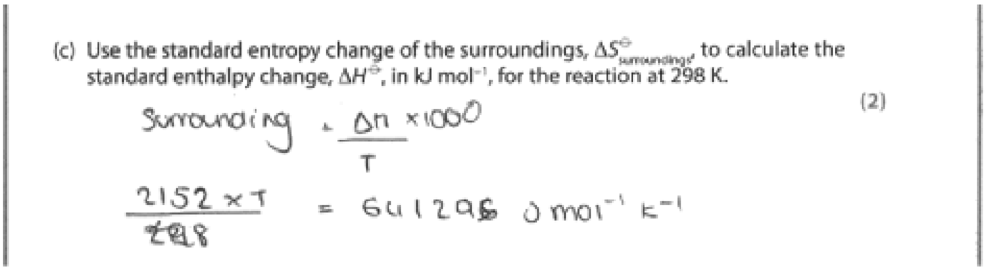
(2)

entropy decreases as 1 mol of gas produces 1 mole of solid

(b) Calculate the total entropy change, $\Delta S^{\ominus}_{total}$, in $J\ mol^{-1}\ K^{-1}$, for this reaction, giving your answer to three significant figures.

(2)

-25.6 + 2152 = + 2126.4 KJ mol^{-1}K^{-1}



(c) Use the standard entropy change of the surroundings, $\Delta S^{\ominus}_{\text{surroundings}}$, to calculate the standard enthalpy change, $\Delta H^{\ominus}$, in kJ mol⁻¹, for the reaction at 298 K.

(2)

$$\text{Surrounding} = \frac{\Delta H}{T} \times 1000$$

$$\frac{2152 \times T}{298} = 641296 \text{ J mol}^{-1} \text{ K}^{-1}$$

ResultsPlus

Examiner Comments

a)(i) The candidate has halved the entropy of chlorine molecules, but still receives some credit as this is the only error.

(ii) This is a reasonable alternative to gas going to solid, so worth 1 mark.

(b) The value is a correct TE but given to 5 SF, worth 1 mark.

(c) The value is correct but the sign is wrong.

ResultsPlus

Examiner Tip

As well as RTQ^2: Check for **S**igns, **U**nits and **S**ignificant figures. (SUS!)

Question 9 (d)(i-iii)

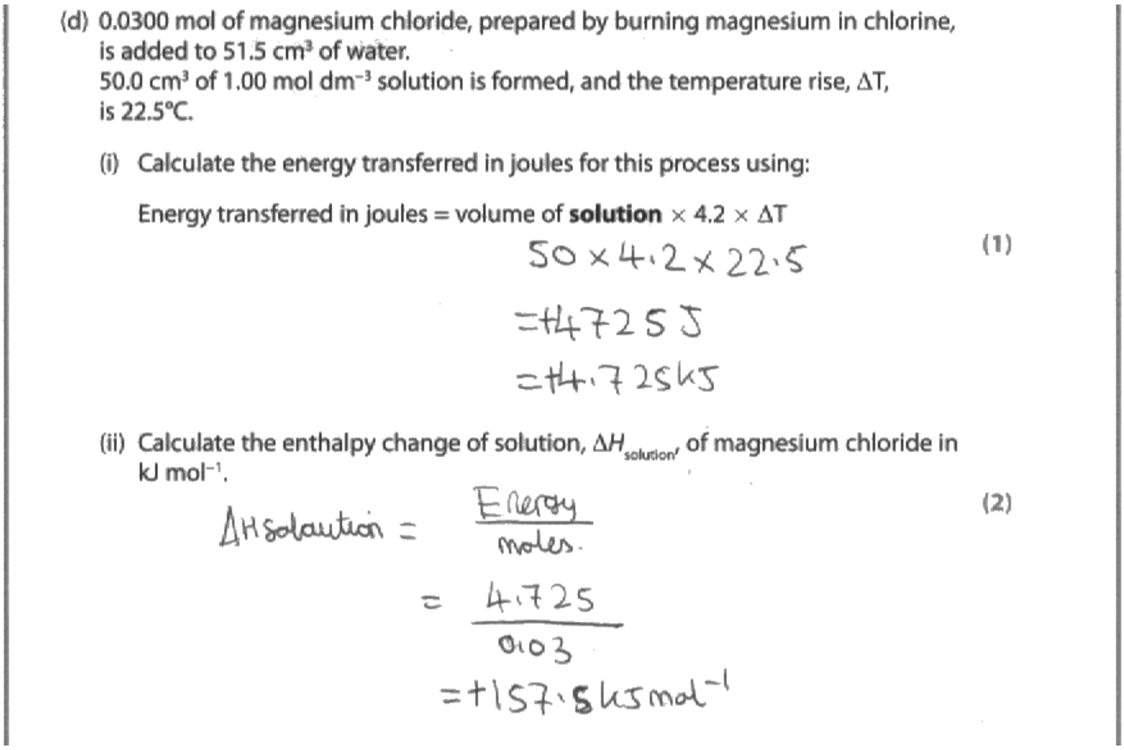
Though the first part was made particularly straightforward by telling candidates they need to use the volume of **solution**, this was often not read. The volume of solvent was used. Some incorrectly converted the volume to dm^3.

In (ii), due to a minor error in the stem of the question, answers based on 0.03 mol and 0.05 mol were both acceptable. However, neither seemed to disadvantage candidates. Even candidates who did both methods seemed to finish the paper strongly and were not affected by the extra time spent.

There were many who attempted to set up new, incorrect Hess cycles. The sign was often omitted.

Part (iii) seemed an unfamiliar calculation to most candidates, but they were not put off, and those with the confidence to apply their skills were successful. It was a good idea to label the cycle with appropriate symbols and apply Hess from there.

Many candidates either left this part blank or left an unintelligible jumble of numbers.



(d) 0.0300 mol of magnesium chloride, prepared by burning magnesium in chlorine, is added to 51.5 cm^3 of water.
50.0 cm^3 of 1.00 mol dm^{-3} solution is formed, and the temperature rise, ΔT, is 22.5°C.

(i) Calculate the energy transferred in joules for this process using:

Energy transferred in joules = volume of **solution** × 4.2 × ΔT

(1)

$50 \times 4.2 \times 22.5$

$= +4725 \text{ J}$

$= +4.725 \text{ kJ}$

(ii) Calculate the enthalpy change of solution, $\Delta H_{solution}$, of magnesium chloride in kJ mol^{-1}.

(2)

$$\Delta H\text{solaution} = \frac{\text{Energy}}{\text{moles}}$$

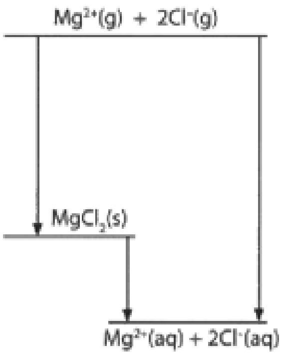
$$= \frac{4.725}{0.03}$$

$$= +157.5 \text{ kJ mol}^{-1}$$

*(iii) The enthalpy change of hydration of $Mg^{2+}(g)$ is –1920 kJ mol^{-1}.

Use this, your value from (d)(ii), and the experimental lattice energy from your Data Booklet, to calculate the enthalpy change of hydration of $Cl^-(g)$.

(3)



$\Delta H_{solution} = -LE + \Delta H_{hydration}$.

$+157.5 = 2526 + -1920 + 2x$

LE of $MgCl_2$ = -2526 $+157.6 = 606 + 2x$

$-449.4 = 2x$

$x = -224.2$

Answer -224.2 kJ mol^{-1}

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Examiner Comments

(i) This is fine with answer in kJ.
(ii) The value is fine but the sign is incorrect, so worth 1 mark.
(iii) This is a well set out calculation, carrying through the transferred error from part (ii), and fully deserves full marks.

(d) 0.0300 mol of magnesium chloride, prepared by burning magnesium in chlorine, is added to 51.5 cm^3 of water. →
50.0 cm^3 of 1.00 mol dm^{-3} solution is formed, and the temperature rise, ΔT, is 22.5°C.

(i) Calculate the energy transferred in joules for this process using:

Energy transferred in joules = volume of **solution** × 4.2 × ΔT

(1)

$$\frac{50}{1000} \times 4.2 \times 22.5$$

$$= 4.725 \text{ joules mol}^{-1}$$

(ii) Calculate the enthalpy change of solution, $\underline{\underline{\Delta H_{solution}}}$, of magnesium chloride in kJ mol^{-1}.

(2)

ΔH_{soln} = solid → gaseous ions.

$= 0.4725$ KJ mol^{-1}

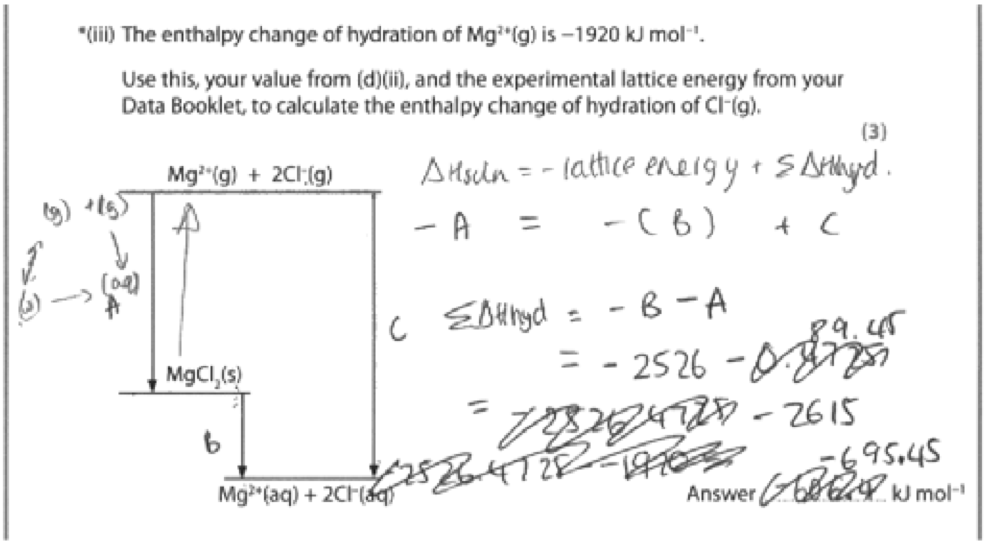
$\div 0.05$

$= \underline{89.45 \text{ KJmol}^{-1}}$

÷ moles.

moles of $MgCl_2$ = 0.

Ex –



*(iii) The enthalpy change of hydration of $Mg^{2+}(g)$ is –1920 kJ mol^{-1}.

Use this, your value from (d)(ii), and the experimental lattice energy from your Data Booklet, to calculate the enthalpy change of hydration of $Cl^-(g)$.

(3)

$\Delta H_{soln} = -\text{lattice energy} + \Sigma \Delta H_{hyd}$.

$-A = -(B) + C$

C $\Sigma \Delta H_{hyd} = -B - A$

$= -2526 - \cancel{0.87257}\ 89.45$

$= \cancel{[illegible]} - 2615$

~~-2526.4728 - 1920~~

-695.45

Answer ~~-6062.4~~ kJ mol^{-1}

ResultsPlus

Examiner Comments

(i) This is out by a factor of 1000 as it is not in kJ.
(ii) They have first divided by 10, then divided by 0.05 (which alone would be fine, of course), but their answer does not agree with that, and the sign is not given.
(iii) The only error is failing to divide by 2 so worth 2 marks.

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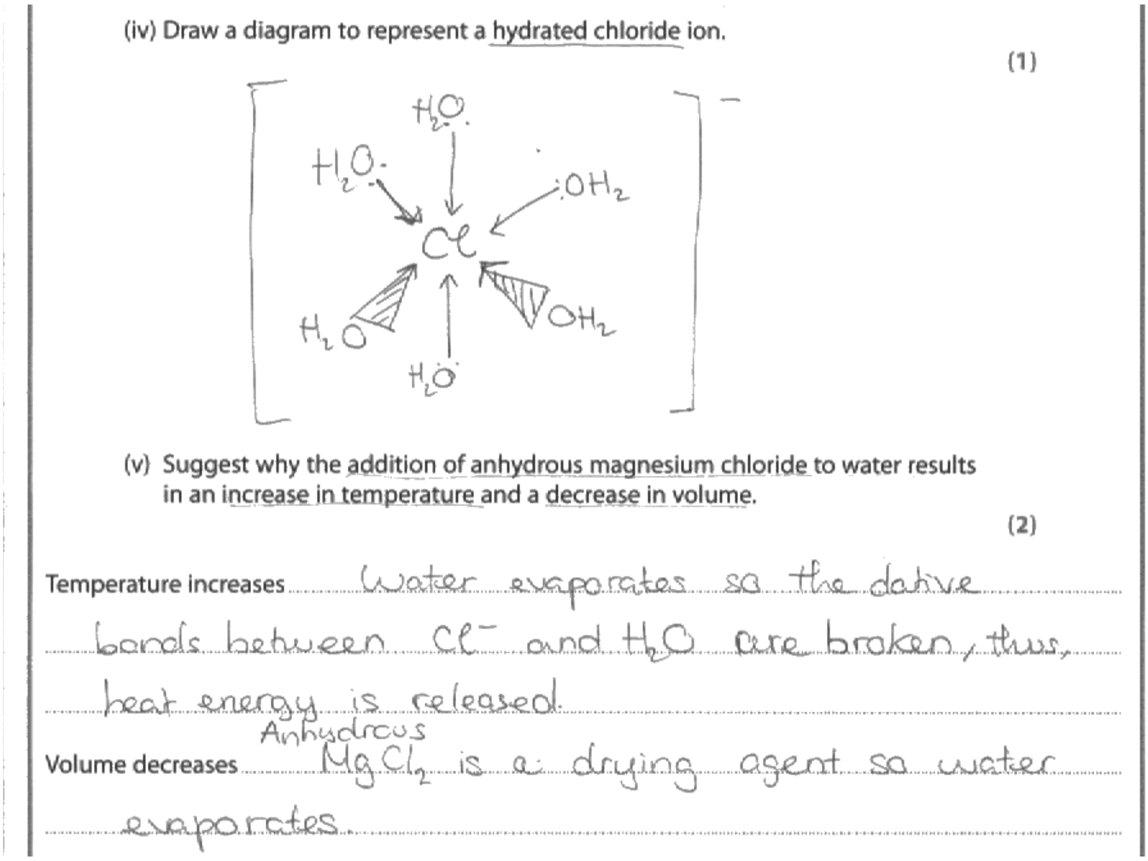
Examiner Tip

Practise this type of calculation.

Question 9 (d)(iv-v)

(iv) Though quite simple, this diagram seemed unknown to most candidates. Common errors were to omit the charge on the chloride ion, to include full charges on oxygen and hydrogen in water, or to bond chloride ions to the oxygen of water.

(v) Many seemed unaware of these changes. However, some were able to work out the correct reasons. There were many incorrect statements about energy changes in bond making and bond breaking. There was confusion between water molecules and ions, like ‘the ions are closer in solution’.



(iv) Draw a diagram to represent a hydrated chloride ion. (1)

(v) Suggest why the addition of anhydrous magnesium chloride to water results in an increase in temperature and a decrease in volume. (2)

Temperature increases Water evaporates so the dative bonds between Cl^- and H_2O are broken, thus, heat energy is released.

Volume decreases Anhydrous $MgCl_2$ is a drying agent so water evaporates.

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Examiner Comments

(iv) This is an instructive incorrect response. The charged ion is shown bonded to water molecules, but bonded through the non-bonding oxygen electrons.

(v) This includes two common errors. First bond breaking does not release energy, it requires an input of energy.

Also, the idea that magnesium chloride is a drying agent does not cause evaporation of water.

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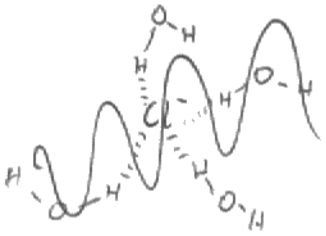
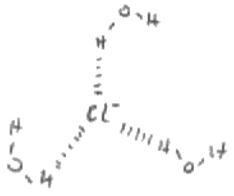
Examiner Tip

Remember bond making releases energy.

(iv) Draw a diagram to represent a hydrated chloride ion.

(1)





(v) Suggest why the addition of anhydrous magnesium chloride to water results in an increase in temperature and a decrease in volume.

(2)

Temperature increases the bonds created between the Mg^{2+} ions and Cl^- ions release energy as bond making is exothermic

Volume decreases the water molecules are highly ordered by the high charge density of the Mg^{2+} ion.

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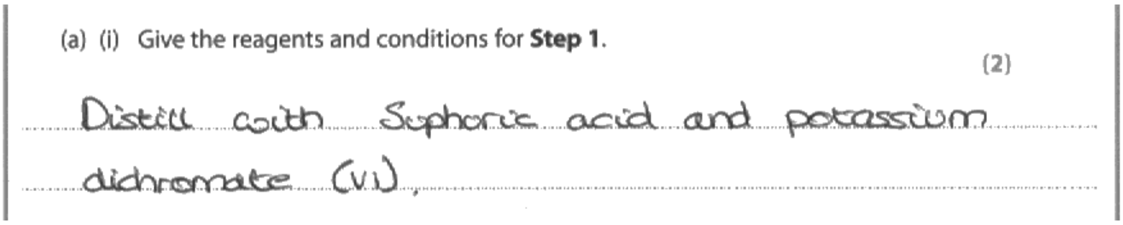
Examiner Comments

An example of two good answers.

Question 10 (a)(i)

Common errors were the omission of any reference to sulfuric acid or omission of the conditions of reflux or distillation.

A few gave incorrect oxidation states or formulae for dichromate.



(a) (i) Give the reagents and conditions for **Step 1**.

(2)

Distill with Suphoric acid and potassium dichromate (VI).

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Examiner Comments

Sulfuric acid and potassium dichromate(VI) is fine.

The acid concentration could be dilute, concentrated, or omitted on this occasion.

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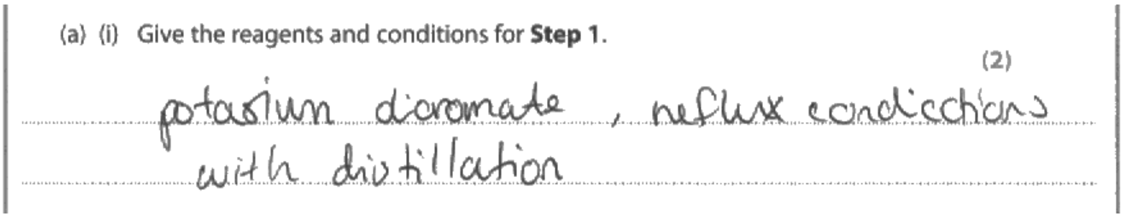
Examiner Tip

'Distil' was fine for conditions, as was 'reflux and distil'.



(a) (i) Give the reagents and conditions for **Step 1**.

(2)

potasium dicromate , reflux condicchions with distillation

ResultsPlus

Examiner Comments

No sulfuric acid so no reagent mark was given.

This was sufficient for the conditions mark, where any mention of dichromate with the correct condition gained this mark.

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Examiner Tip

Always learn names and formula of reactants and details of conditions, for organic reactions.

Question 10 (a)(ii)

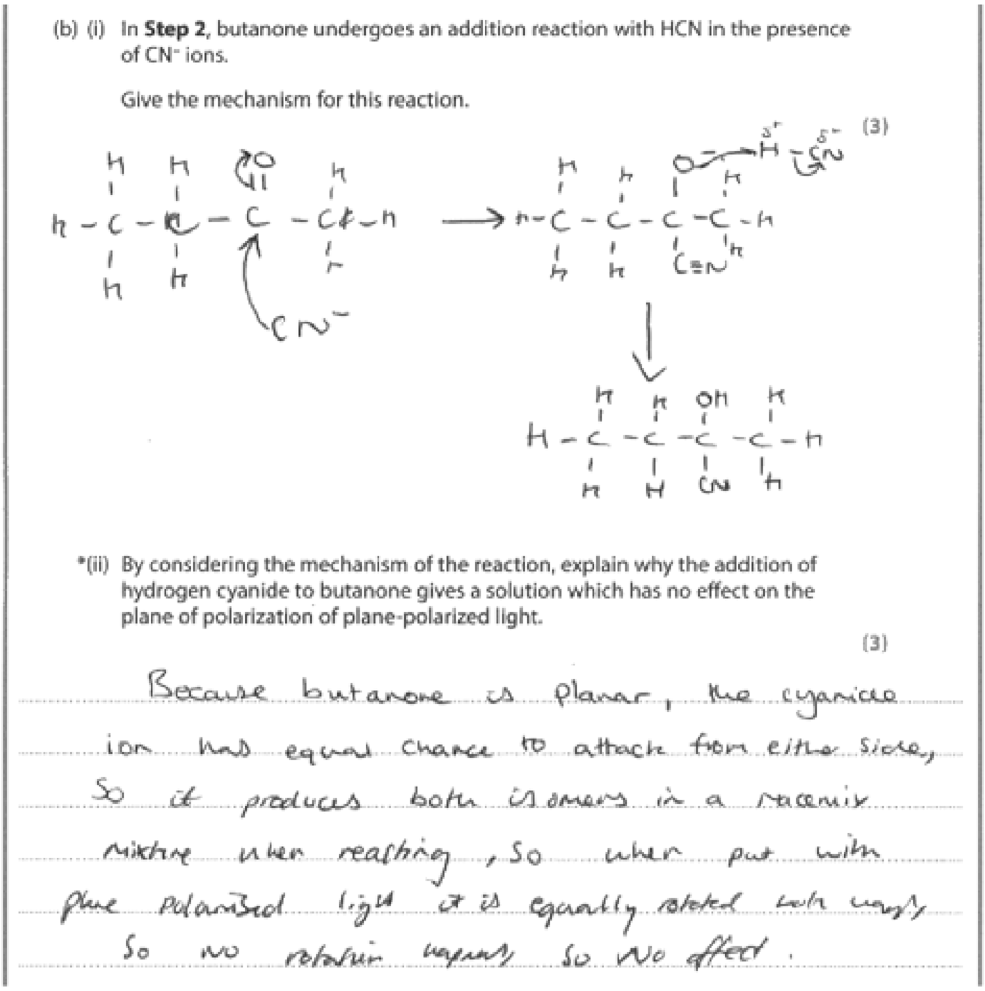
A few weak candidates gave the state of the product in either part as a solution.

The detail of the second test was often lacking. ‘Iodoform gives a yellow precipitate’ was typical and gained the fourth mark but not the third.

Question 10 (b)(i-ii)

In part (i) common errors were the omission of the charge on the attacking cyanide ion or the negative charge on oxygen in the intermediate. Some arrows went in the wrong direction, particularly from hydrogen to the oxygen in the final step.

In part (ii) many said butanone is planar, which is not true. A few thought a racemic mixture would not form.



(b) (i) In **Step 2**, butanone undergoes an addition reaction with HCN in the presence of CN⁻ ions.

Give the mechanism for this reaction.

(3)

*(ii) By considering the mechanism of the reaction, explain why the addition of hydrogen cyanide to butanone gives a solution which has no effect on the plane of polarization of plane-polarized light.

(3)

Because butanone is planar, the cyanide ion has equal chance to attach from either side, so it produces both isomers in a racemix mixture when reacting, so when put with plane polarised light it is equally rotated both ways so no rotation happens so no affect.

ResultsPlus

Examiner Comments

This is fine, but for the statement in part (ii) that butanone is planar.

ResultsPlus

Examiner Tip

The key feature of this nucleophilic addition is the planarity of the bonds around the carbon of the carbonyl group.

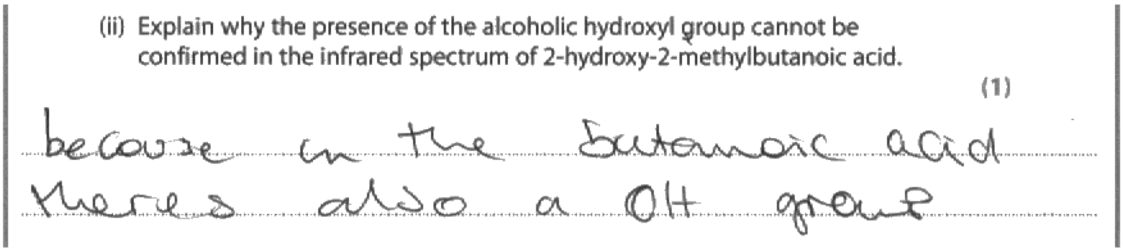
Question 10 (c)(i)

As usual there were many candidates who confused reaction types giving answers like nucleophilic substitution.

More instructive were those who gave hydration.

The difference between hydration and hydrolysis needs to be understood. Hydration only involves bond making. Hydrolysis, as the ending implies, is bonds breaking and making.

Question 10 (c)(ii)



(ii) Explain why the presence of the alcoholic hydroxyl group cannot be confirmed in the infrared spectrum of 2-hydroxy-2-methylbutanoic acid.

(1)

because in the butanoic acid
theres also a OH group

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Examiner Comments

This was the most common insufficient answer.

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Examiner Tip

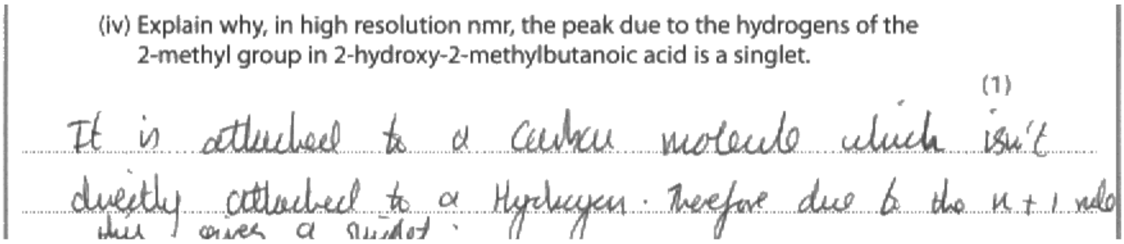
Check to see that each question is answered as fully as possible.

Question 10 (c)(iii)

Incorrect values between 10 and 13 were quite common.

Question 10 (c)(iv)

The answer should say that there are no hydrogen atoms attached to the adjacent carbon atom.



(iv) Explain why, in high resolution nmr, the peak due to the hydrogens of the 2-methyl group in 2-hydroxy-2-methylbutanoic acid is a singlet.

(1)

It is attached to a carbon molecule which isn't directly attached to a Hydrogen. Therefore due to the n+1 rule this gives a singlet.

ResultsPlus

Examiner Comments

There are two instructive errors in this response. The first which costs the mark is the reference to the adjacent carbon molecule, rather than atom.

A minor point is writing outside the space provided. If this happens it is best to signal this in the lined space, to ensure the examiners know.

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Examiner Tip

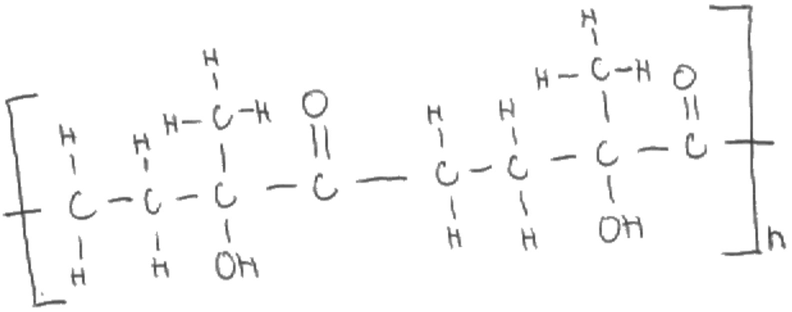
Signal responses which overrun the space given with 'please see below' or 'please see page xx'.

Question 10 (d)

(d) Molecules of 2-hydroxy-2-methylbutanoic acid react together to form a condensation polymer.

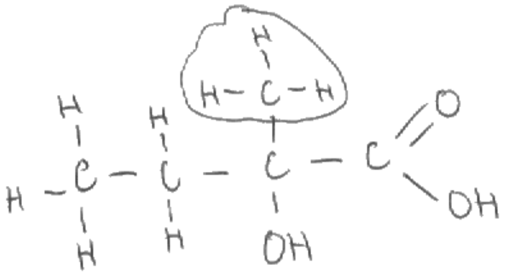
Draw a **displayed** formula for this polymer, showing two repeating units.

(2)



+ nH_2O

(Total for Question 10 = 18 marks)



Examiner Comments

This answer illustrates two typical mistakes.

First the connection between molecules is by a ketone group.

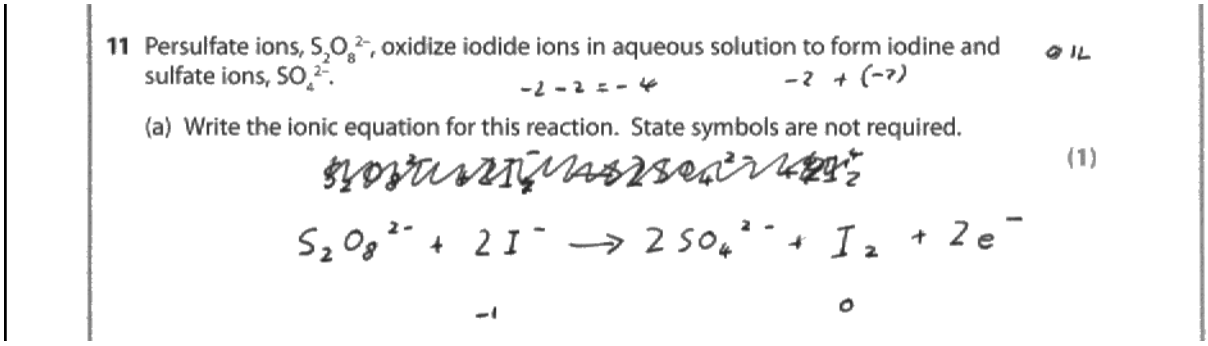
Second the carbon framework is incorrect.

Examiner Tip

Practise writing polyester formulae.

Question 11 (a)

Some errors occurred in balancing the equation. Some added or removed electrons.



11 Persulfate ions, $S_2O_8^{2-}$, oxidize iodide ions in aqueous solution to form iodine and sulfate ions, SO_4^{2-}.

$-2 - 2 = -4$ $-2 + (-?)$ 0 IL

(a) Write the ionic equation for this reaction. State symbols are not required. (1)

$S_2O_8^{2-} + 2I^- \rightarrow 2SO_4^{2-} + I_2 + 2e^-$

-1 0

ResultsPlus

Examiner Comments

A common error - the entities are correct but two extra electrons are added.

ResultsPlus

Examiner Tip

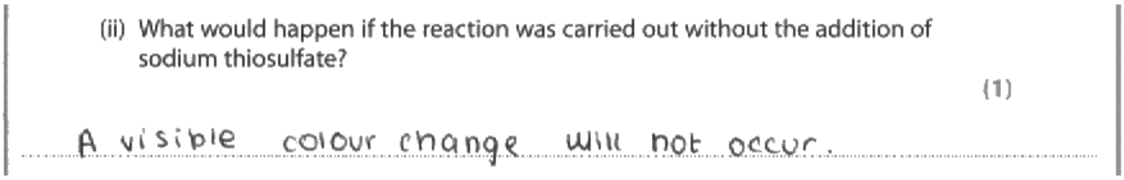
If oxidation number changes balance, so do electrons.

Question 11 (b)(i)

This with the other parts of (b) was very discriminating. Colourless was the most common response.

Question 11 (b)(ii)

The key was to mention the immediate change of colour.



(ii) What would happen if the reaction was carried out without the addition of sodium thiosulfate?

(1)

A visible colour change will not occur.

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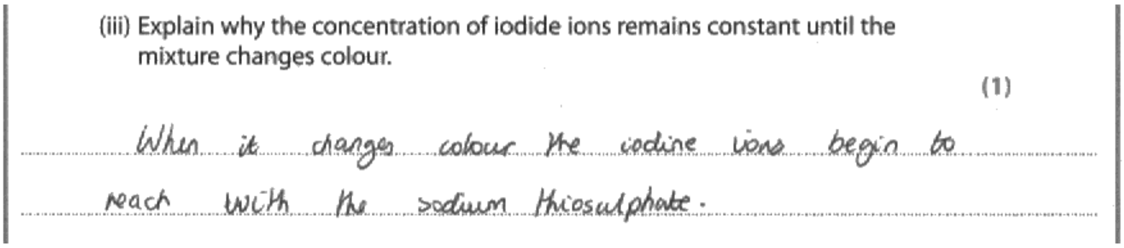
Examiner Comments

This candidate deserves some sympathy. They have answered the question in part but failed to give sufficient detail. The reason no change would be seen is because the blue-black colour would form immediately.

Question 11(b)(iii)

A reasoned chemical answer was needed here.

Ideally this should have been something about the thiosulfate reducing iodine to iodide as soon as it formed.



(iii) Explain why the concentration of iodide ions remains constant until the mixture changes colour.

(1)

When it changes colour the iodine ions begin to react with the sodium thiosulphate.

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Examiner Comments

A typical muddled response. Notice the reference to iodine rather an iodide ions. The second part of the answer is totally wrong. The reaction changes colour when all the thiosulfate ions have reacted.

Question 11 (c)

In part (c)(i) the axes were usually the correct way round but labels or units were missing. Scales were often too small or running in the wrong direction. The points were sometimes incorrectly plotted or a straight line not drawn.

In part (ii) weaker candidates gave ‘zero order as the graph is a straight line’ which gained no credit.

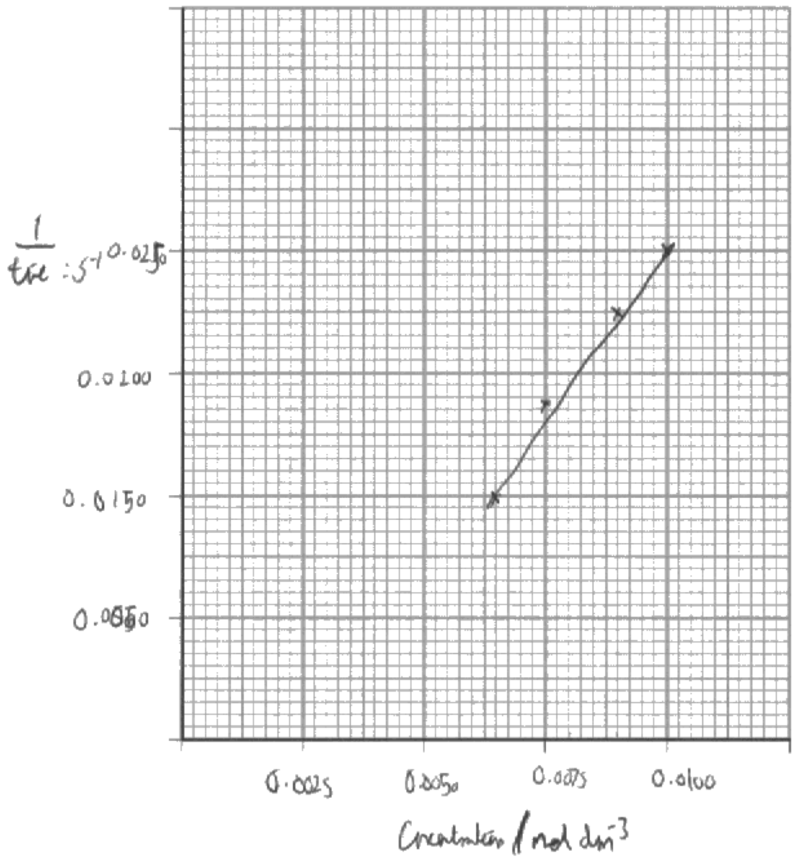
In part (iii) the rate constant was often missed. The unit had to be consistent. A transferred error was allowed from part (ii).

(c) The results obtained from the experiment in part (b) were tabulated as follows.

$[S_2O_8^{2-}]$ /mol dm^{-3}	Time /s	1/time /s^{-1}
0.0100	40.0	0.0250
0.0090	44.4	0.0225
0.0075	53.3	0.0188
0.0060	66.7	0.0150

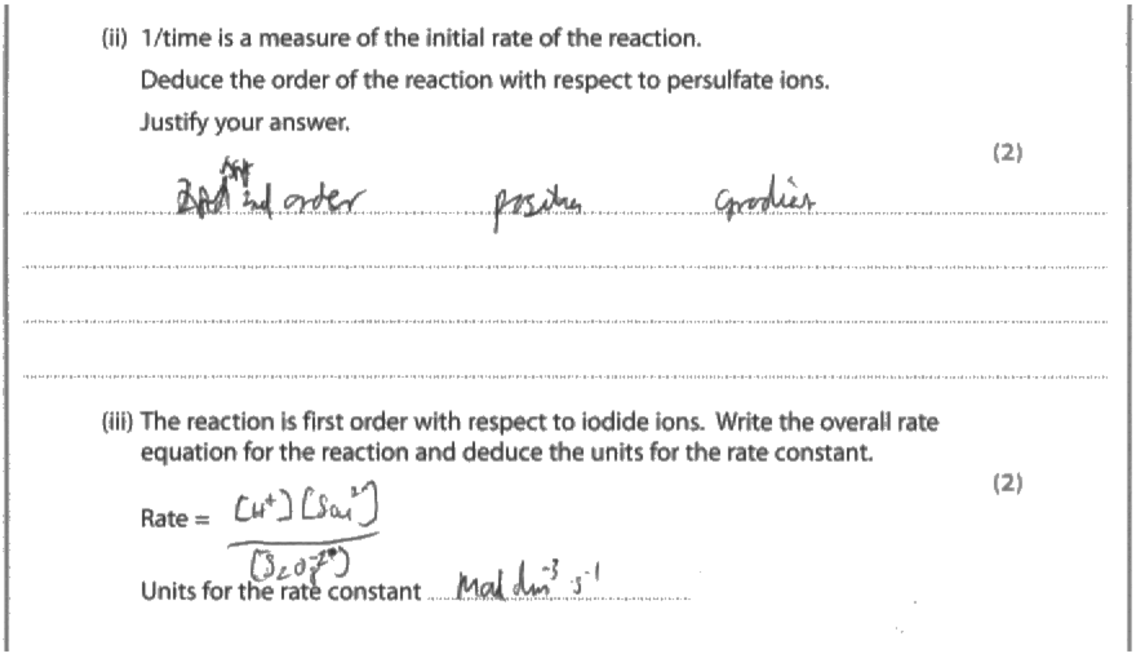
(i) Plot a graph of 1/time on the vertical axis against the concentration of the persulfate ions.

(2)



$\frac{dy}{dx} = \frac{0.0250 - 0.015}{0.0100 - 0.0060}$

$= 2.5$



(ii) 1/time is a measure of the initial rate of the reaction.

Deduce the order of the reaction with respect to persulfate ions.

Justify your answer.

(2)

2nd order positive gradient

(iii) The reaction is first order with respect to iodide ions. Write the overall rate equation for the reaction and deduce the units for the rate constant.

(2)

Rate = $\frac{[H^+][SO_4^{2-}]}{[S_2O_8^{2-}]}$

Units for the rate constant Mol dm^{-3} s^{-1}

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Examiner Comments

(i) While the axes are the correct way round and correctly labelled, the scales are too small. The points are incorrectly plotted and a straight line is not drawn.

(ii) The order is not second.

(iii) The rate constant is missing and the terms are wrong. The unit is not consistent with the terms.

ResultsPlus

Examiner Tip

Practise different types of graphical determinations of rates.

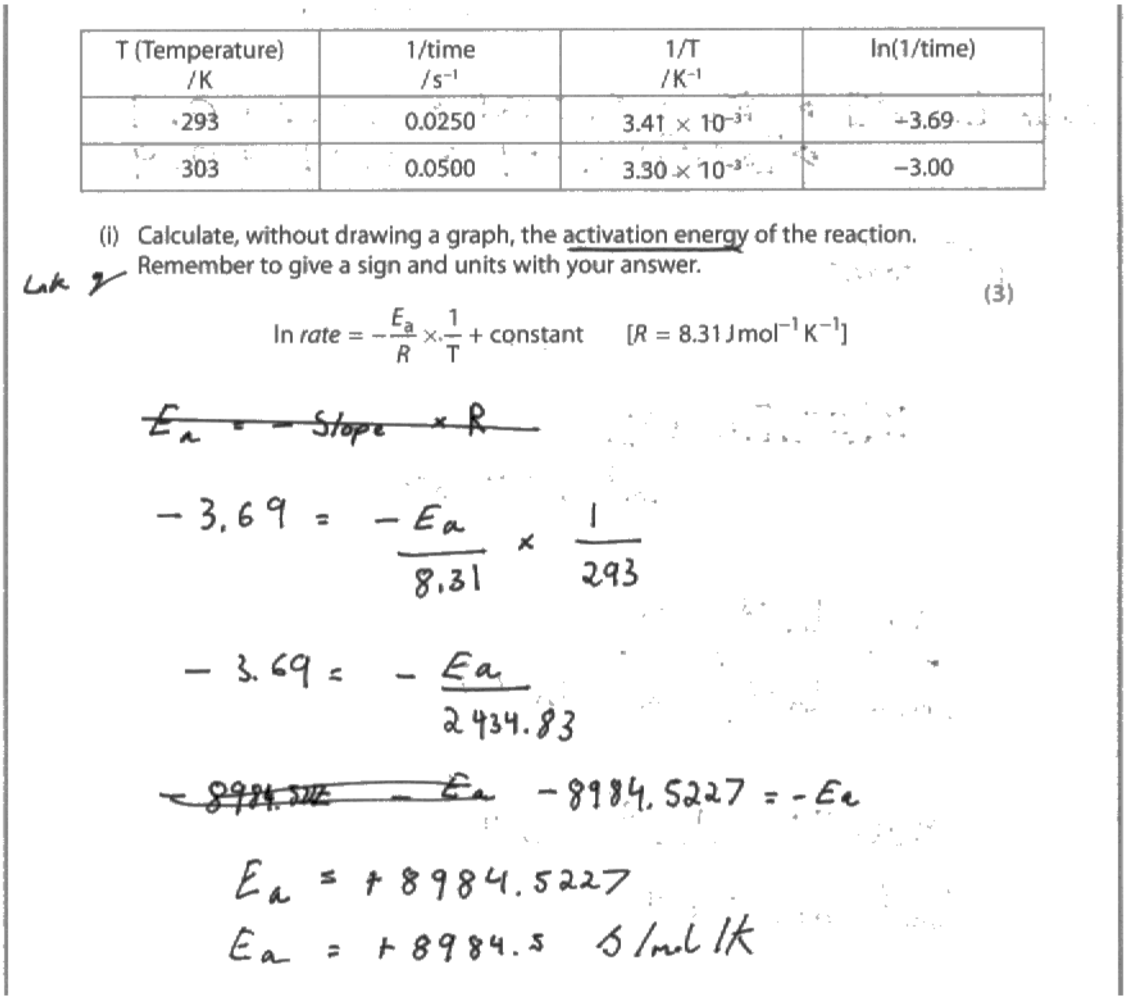
Question 11 (d)(i)

Though this question was set slightly differently to the usual as only two values were given, the majority of candidates knew how to find the gradient of the line between them.

Some correctly solved two simultaneous equations.

Both methods were acceptable.

Both required care with signs, powers of ten, and units.



T (Temperature) /K	1/time /s^{-1}	1/T /K^{-1}	ln(1/time)
293	0.0250	3.41×10^{-3}	−3.69
303	0.0500	3.30×10^{-3}	−3.00

(i) Calculate, without drawing a graph, the activation energy of the reaction. Remember to give a sign and units with your answer.

Lak y

(3)

$$\ln rate = -\frac{E_a}{R} \times \frac{1}{T} + \text{constant} \qquad [R = 8.31\,\text{J}\,\text{mol}^{-1}\,\text{K}^{-1}]$$

~~$E_a = -\text{Slope} \times R$~~

$$-3.69 = -\frac{E_a}{8.31} \times \frac{1}{293}$$

$$-3.69 = -\frac{E_a}{2434.83}$$

~~$-8984.52 \quad -E_a$~~ $-8984.5227 = -E_a$

$E_a = +8984.5227$

$E_a = +8984.5$ J/mol/K

ResultsPlus

Examiner Comments

This was a common error to ignore the constant in the relationship, and attempt a simple substitution. It showed a total lack of understanding and gained no credit.

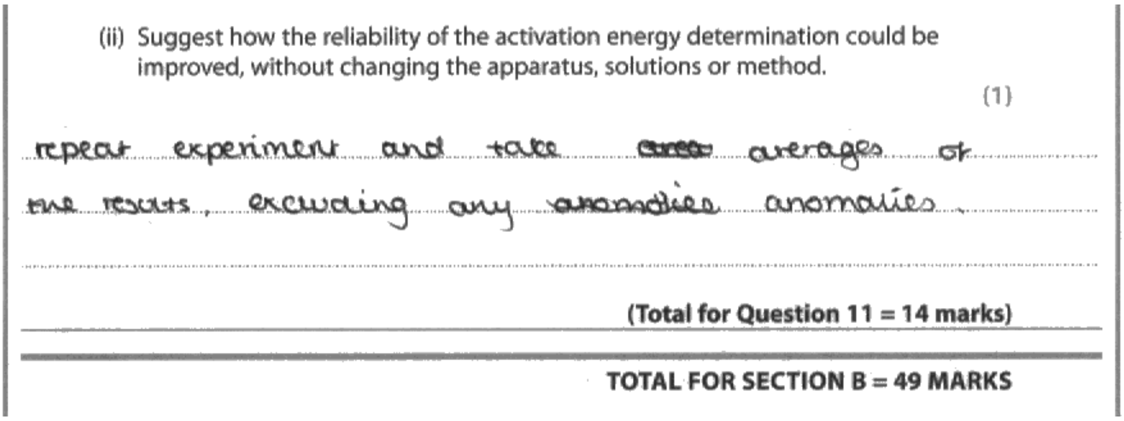
Of course, if the constant had been included, the second equation written and the simultaneous equation solved then full marks were possible.

ResultsPlus

Examiner Tip

Practise activation energy calculations.

Question 11 (d)(ii)



(ii) Suggest how the reliability of the activation energy determination could be improved, without changing the apparatus, solutions or method.

(1)

repeat experiment and take ~~[illegible]~~ averages of the results, excluding any ~~anomdies~~ anomalies.

(Total for Question 11 = 14 marks)

TOTAL FOR SECTION B = 49 MARKS

ResultsPlus
Examiner Comments

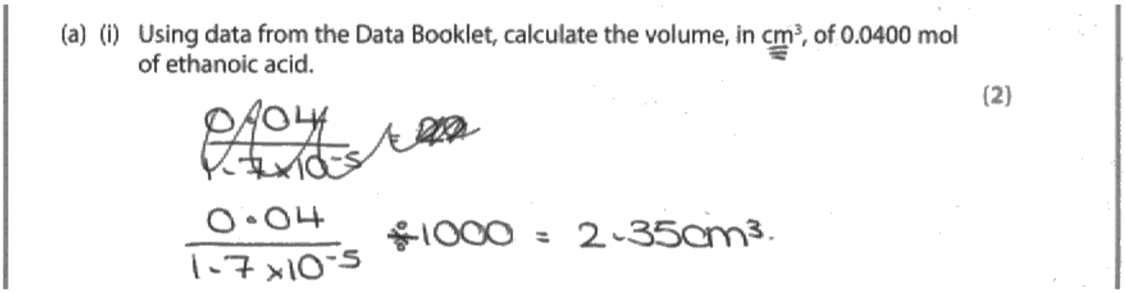
This was a sufficient answer.

Question 12 (a)(i)

A great many candidates tried to work this out from K_a for ethanoic acid, which could not be done and gained no credit.

Many calculated the mass of 0.04 mol correctly but gave 2.4 cm^3 which gained no credit.

The relationship between density, volume and mass is crucial to Chemistry and should be thoroughly learned with each quantity as the subject.



(a) (i) Using data from the Data Booklet, calculate the volume, in cm^3, of 0.0400 mol of ethanoic acid.

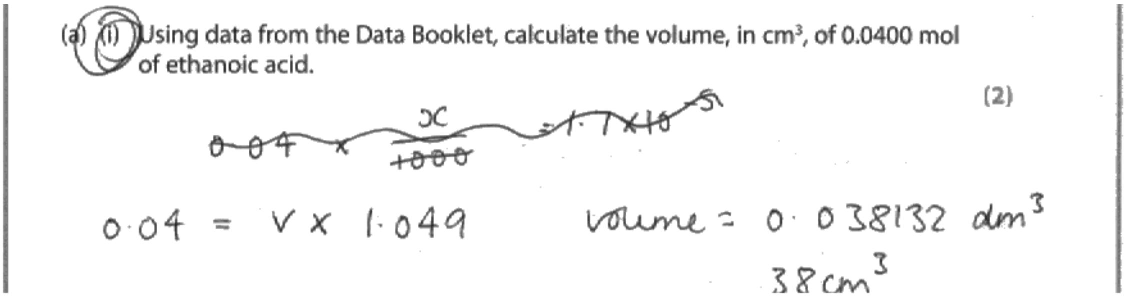
(2)

~~$\frac{0.04}{1.7\times10^{-5}}$~~

$\frac{0.04}{1.7\times10^{-5}} \div 1000 = 2.35cm^3.$

ResultsPlus
Examiner Comments

This is a typical attempt to use K_a.



(a) (i) Using data from the Data Booklet, calculate the volume, in cm^3, of 0.0400 mol of ethanoic acid.

(2)

~~0·04 × $\frac{x}{1000}$ = $1·7\times10^{-5}$~~

0·04 = V × 1·049   volume = 0·038132 dm^3

38 cm^3

ResultsPlus

Examiner Comments

Division of 0.04 by the density is not sufficient for the second mark, and this is even worse here as 0.04 is multiplied by the density.

ResultsPlus

Examiner Tip

Learn the relationships between density, mass and volume.

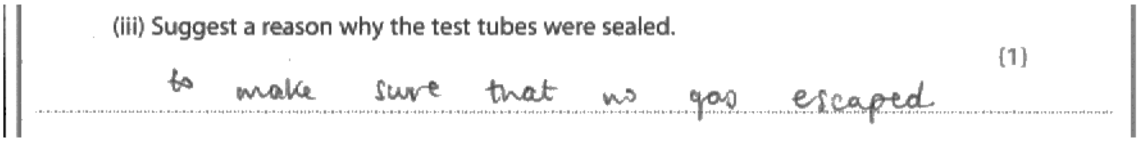
Question 12 (a)(ii)

The apparatus used to measure out 2.29 cm^3 of liquid accurately is a graduated pipette or syringe.

Most omitted the word graduated and failed to score.

Question 12 (a)(iii)

There were several acceptable answers to part (iii). The best gave a full explanation of the reason, for example, 'to prevent reaction with oxygen present in air', or 'to prevent evaporation of the volatile organic chemicals'.



(iii) Suggest a reason why the test tubes were sealed.

(1)

to make sure that no gas escaped

ResultsPlus

Examiner Comments

This was the most common insufficient answer.

ResultsPlus

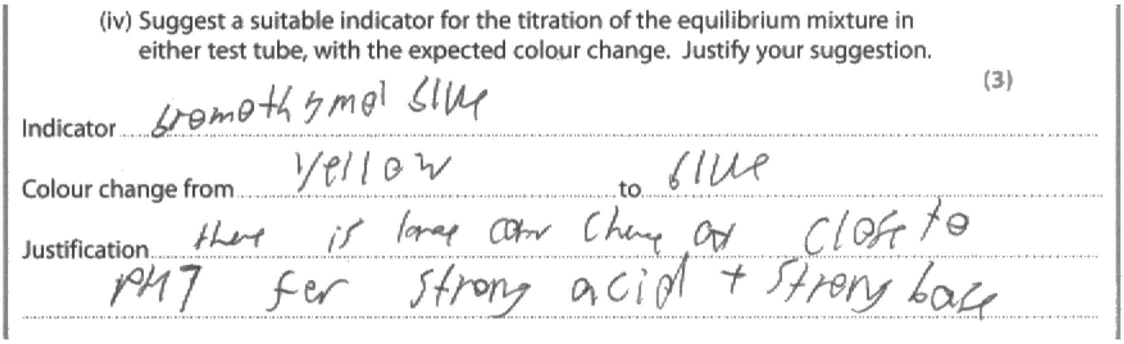
Examiner Tip

When a liquid evaporates below its boiling temperature it becomes a **vapour**.

Question 12 (a)(iv)

Many chose unfamiliar indicators, which was fine if they would work and the correct colour change given for the titration of an acid by addition of alkali.

The reason mark was independent but difficult to score for an incorrect selection. Clearly methyl orange would not change at the end/equivalence point of the reaction.



(iv) Suggest a suitable indicator for the titration of the equilibrium mixture in either test tube, with the expected colour change. Justify your suggestion.

(3)

Indicator bromothymol blue

Colour change from yellow to blue

Justification there is large colr change at close to pH7 for strong acid + strong base

ResultsPlus

Examiner Comments

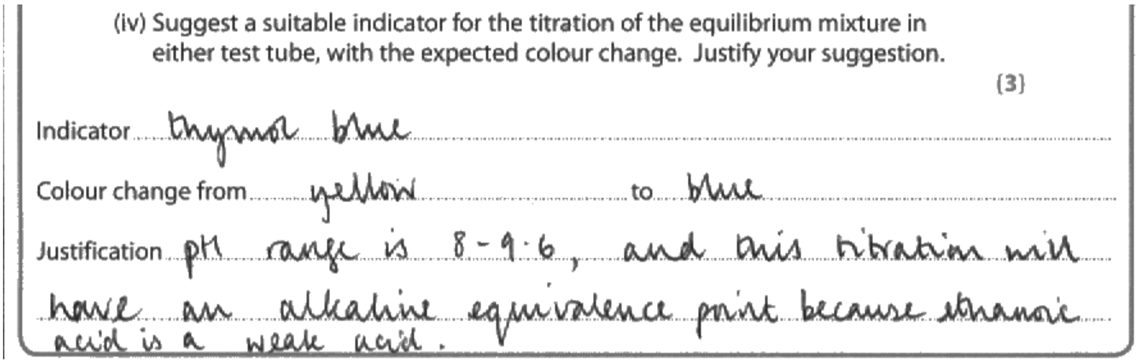
This answer gained one mark for the correct colour change for this indicator which is just out of range.

Notice the reason omits mention of the weak acid involved.

ResultsPlus

Examiner Tip

It is best to go with what you have learned - phenolphthalein is the obvious selection.



(iv) Suggest a suitable indicator for the titration of the equilibrium mixture in either test tube, with the expected colour change. Justify your suggestion.

(3)

Indicator thymol blue

Colour change from yellow to blue

Justification pH range is 8-9.6, and this titration will have an alkaline equivalence point because ethanoic acid is a weak acid.

ResultsPlus

Examiner Comments

An example of an excellent answer.

ResultsPlus

Examiner Tip

Practise selecting indicators.

Question 12 (b)

(i) A few candidates gave the formula for methanol or were unable to give an ester formula.

(ii) Very few realised that the titre for hydrochloric acid had to be subtracted before finding the amount of ethanoic acid in the mixture.

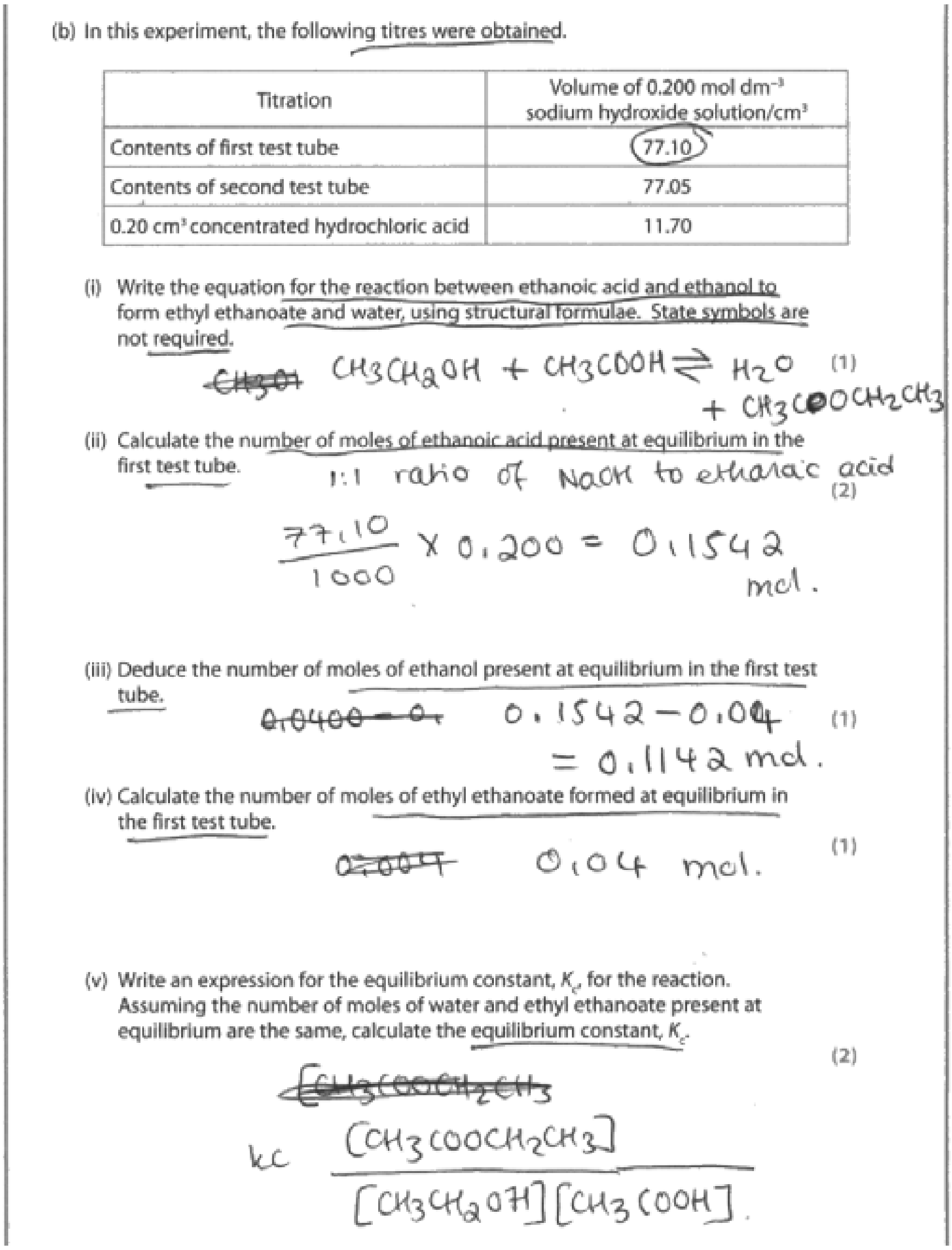
(iii) Few did not give the same amount here as in (ii).

(iv) Many candidates could not use the equation for the reaction to work out this amount.

(v) Though most could write the expression for the equilibrium constant, many had already given up, or gave up after writing it.

(vi) Almost everyone realised that the units would cancel, even if they had given up on the calculation. A few wrongly gave just 'there are the same number of chemicals on each side of the equation.

(vii) Very few realised that concentrated hydrochloric acid contains some water despite HCl being a gas.



(b) In this experiment, the following titres were obtained.

Titration	Volume of 0.200 mol dm^{-3} sodium hydroxide solution/cm^3
Contents of first test tube	77.10
Contents of second test tube	77.05
0.20 cm^3 concentrated hydrochloric acid	11.70

(i) Write the equation for the reaction between ethanoic acid and ethanol to form ethyl ethanoate and water, using structural formulae. State symbols are not required. (1)

~~CH_3OH~~ $CH_3CH_2OH + CH_3COOH \rightleftharpoons H_2O + CH_3COOCH_2CH_3$

(ii) Calculate the number of moles of ethanoic acid present at equilibrium in the first test tube. (2)

1:1 ratio of NaOH to ethanaic acid

$\frac{77.10}{1000} \times 0.200 = 0.1542$ mol.

(iii) Deduce the number of moles of ethanol present at equilibrium in the first test tube. (1)

~~0.0400 − 0.~~ $0.1542 - 0.04$

$= 0.1142$ mol.

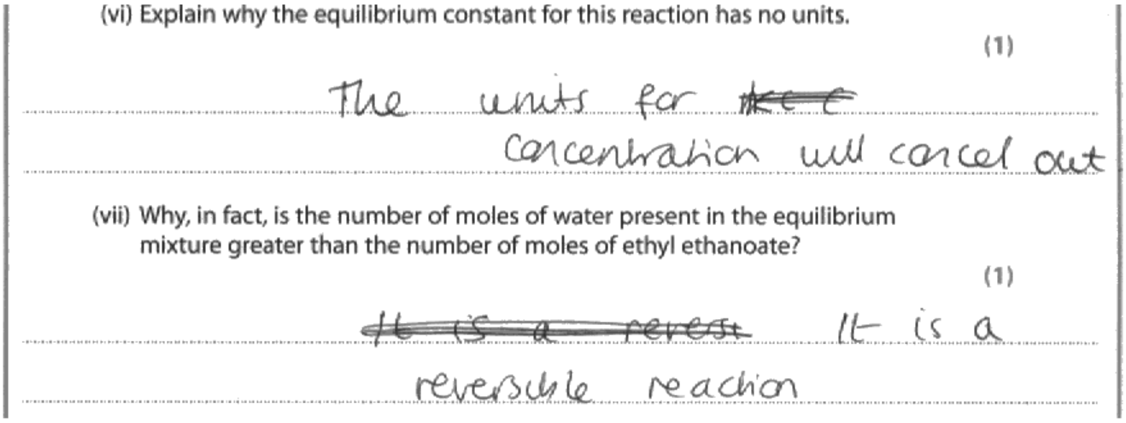
(iv) Calculate the number of moles of ethyl ethanoate formed at equilibrium in the first test tube. (1)

~~0.004~~ 0.04 mol.

(v) Write an expression for the equilibrium constant, K_c, for the reaction. Assuming the number of moles of water and ethyl ethanoate present at equilibrium are the same, calculate the equilibrium constant, K_c. (2)

~~$[CH_3COOCH_2CH_3$~~

$$kc \quad \frac{[CH_3COOCH_2CH_3]}{[CH_3CH_2OH][CH_3COOH]}.$$



(vi) Explain why the equilibrium constant for this reaction has no units.

(1)

The units for ~~the c~~ concentration will cancel out

(vii) Why, in fact, is the number of moles of water present in the equilibrium mixture greater than the number of moles of ethyl ethanoate?

(1)

~~It is a revers~~ It is a reversible reaction

ResultsPlus

Examiner Comments

(i) The equation is fine

(ii)This gains one mark as the total amount of hydroxide ion and hence oxonium ions are found, but those from the hydrochloric acid are ignored.

(iii) and (iv) have nothing of value.

(v) The numerator is missing the concentration of water. There is no attempt at a calculation.

(vi) This is fine.

(vii) An answer to a later question!

ResultsPlus

Examiner Tip

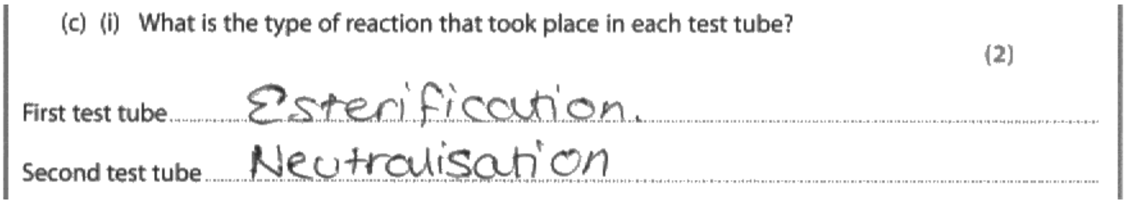
Practise equilibrium calculations based on experiments.

Question 12 (c)(i)

These reaction types were generally well known.

A few gave them the wrong way round.

The hydrolysis reaction was the less well known.



(c) (i) What is the type of reaction that took place in each test tube?

(2)

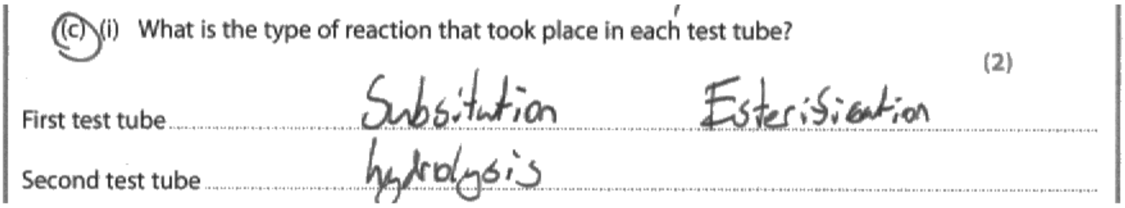
First test tube Esterification.

Second test tube Neutralisation

ResultsPlus
Examiner Comments

The first part is fine.

The second is not true.



(c) (i) What is the type of reaction that took place in each test tube?

(2)

First test tube Subsitution Esterisiation

Second test tube hydrolysis

ResultsPlus
Examiner Comments

This gains the second mark only.

ResultsPlus
Examiner Tip

It is unwise to give two answers unless certain both are correct.

Question 12(c)(ii)

A common error was to say the values were the same, which they were not.

It is best to say they are concordant, or they are within tolerance of each other.

Many talked about equilibrium being a dynamic state, which was not accepted as it missed the key point demonstrated by this experiment, that equilibrium reaction are reversible.

Question 12 (c)(iii)

A straightforward finish where most recognised the catalytic role of hydrochloric acid as a source of protons.

Paper Summary

To improve their performance candidates should draw on both theory and their practical work to:

- practise calculations of entropy changes, hydration energies, activation energies and equilibrium constants.
- practise plotting rate graphs.
- always consider the reasons and explanations for result of practical work or calculations.
- learn the organic reactions, with names and formulae of reactants and products, conditions, and tests for and uses of products.

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