Examiners' Report
June 2017

IAL Chemistry WCH04 01

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Introduction

The paper seemed to be well received. There was no evidence of candidates having insufficient time to complete the paper.

There were twelve items where many candidates struggled but all questions attracted the full range of marks. There were a number of questions where the style of the question, or the area of the specification covered was less familiar to the candidates. There were also several questions requiring candidates to apply their knowledge to novel situations.

As is usual, there were questions on practical areas of this unit, which were only well done by good candidates. There were many excellent answers from centres where practical work is given the priority needed but there were also candidates who showed little experience of working in laboratories.

Many candidates struggled to read values from graphs.

They also struggled to deduce reaction order from experimental rate data.

Many candidates seemed to be unfamiliar with the different types of organic formulae and equations for organic reactions met in this Unit.

There were numbers of questions where candidates failed to read the question asked.

Multiple choice questions 1 – 15

The questions with the greatest number of correct responses were:

4a – calculation of pH for a strong acid;

5a – effect of changing conditions on an equilibrium;

14b – identification of ion for a mass spectrum peak.

The questions with the fewest number of correct responses were:

11 – reason for hydrogenation of vegetable oils;

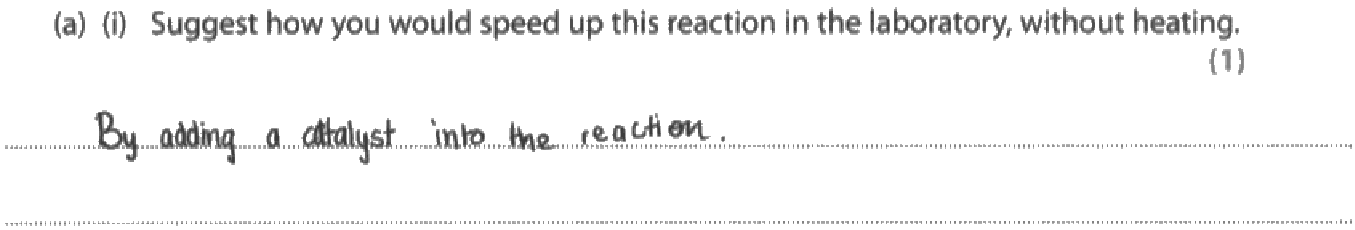
10 – enthalpy changes when a solid dissolves in water;

7 – reactions of ethanoyl chloride.

Question 16 (a) (i)

This practical question was challenging, though the reaction is in the specification.

Most centres get the candidates to stir the mixture with a thermometer.



(a) (i) Suggest how you would speed up this reaction in the laboratory, without heating.
(1)

By adding a catalyst into the reaction.

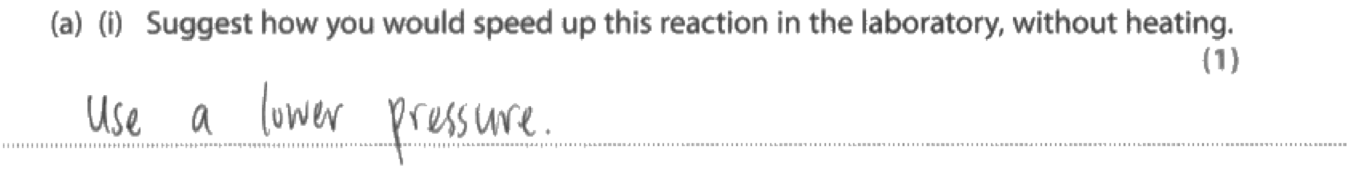
ResultsPlus
Examiner Comments

This was the most common insufficient answer.

Mark 0

ResultsPlus
Examiner Tip

Try to recall what you did in an experiment.



(a) (i) Suggest how you would speed up this reaction in the laboratory, without heating.
(1)

Use a lower pressure.

ResultsPlus
Examiner Comments

This is a common confusion between rates and equilibria.
It is not as bad as those who did not read the question and heated the mixture.
Mark 0

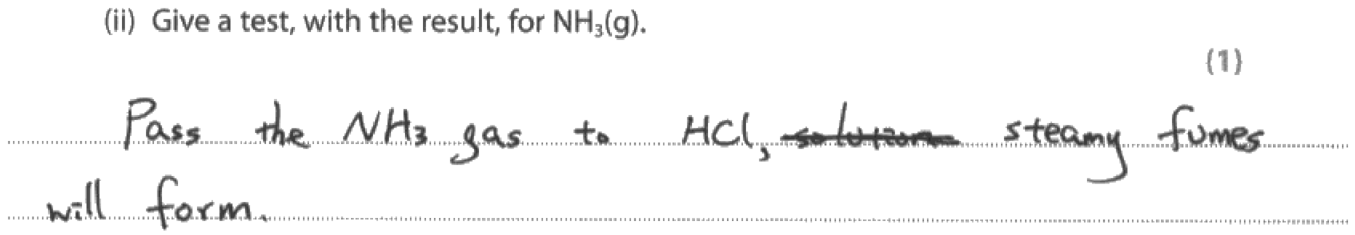
ResultsPlus
Examiner Tip

Learn the factors that increase reaction rates.

Question 16 (a) (ii)

Though this test should be familiar to all candidates, fewer than half gave a correct test.

The use of **damp** red litmus paper was the most common correct response.



(ii) Give a test, with the result, for $NH_3(g)$.

(1)

Pass the NH_3 gas to HCl, ~~solution~~ steamy fumes will form.

ResultsPlus

Examiner Comments

There are two problems with this answer:

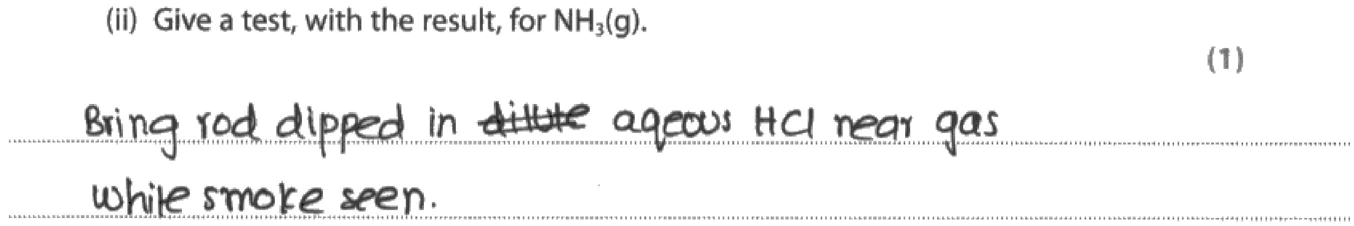
hydrogen chloride **gas** is needed; and white smoke is produced, not steamy fumes.

Mark 0

ResultsPlus

Examiner Tip

Learn the tests for common substances from the User Guide.



(ii) Give a test, with the result, for $NH_3(g)$.

(1)

Bring rod dipped in ~~dilute~~ aqeous HCl near gas white smoke seen.

ResultsPlus

Examiner Comments

This would not always work: the rod should be dipped in concentrated hydrochloric acid.
Mark 0

ResultsPlus

Examiner Tip

Try to recall the test you used fully.

Question 16 (b) (c)

This whole calculation is one many centres set as a homework exercise, after carrying out the experiment and explanation of the various entropy values.

As usual it proved a good source of marks for all but the weakest candidates.

In part (i) you needed to use the correct values, subtract the reactant values from the product values, after multiplying by the stoichiometric amounts. The sign and correct units, including the indices were required.

Signs and/or units were often omitted from parts (i) and (iii).

(b) (i) Calculate the standard entropy change for the system, $\Delta S^{\ominus}_{system}$, for this reaction.

Include a sign and units in your answer.

The standard entropy of $BaCl_2.2H_2O(s)$ is +202.9 J K^{-1} mol^{-1}.

Use your Data Booklet for the other values.

(3)

Ba- 62.8 Cl-82.5 H- 65.3 O- 102.S

S°-(62.8)+(82.5^2)+(65.3)^2+(102.S)

= 460.9 J K^{-1} mol^{-1}

(ii) Is the sign for the standard entropy change of the system, $\Delta S^{\ominus}_{system}$, as you would expect? Justify your answer.

(1)

No S° [illegible] is the sign ~~for~~ standard entropy change whereas stardard entropy change of the SYSTEM is $\Delta S^{\circ}_{system}$

(c) (i) The total standard entropy change, $\Delta S^{\ominus}_{\text{total}}$, is +227.5 J K^{-1} mol^{-1}.

Calculate the standard enthalpy change, $\Delta H^{\ominus}$, for this reaction at 298 K.

Include a sign and units in your answer.

(3)

Cl	Ba	H	O
82.5	62.8	65.3	102.5

$\leftarrow (S^{\ominus})$

$= 460.9 \cdot S^{\ominus}$

$= 460.9 \text{ J K}^{-1} \text{mol}^{-1}$

(ii) State and explain how you would expect the temperature to change during this reaction.

(1)

Through the electrons movements temperature and energy is produced.

ResultsPlus

Examiner Comments

There is nothing to gain marks in these answers.

(b)(i) The candidate has effectively reset the question - there can be no credit for this.

(b)(ii) No mention of a sign.

(c)(i) Like (b)(i).

(c)(ii) No mention of rise in temperature.

Marks 0 0 0 0

(b) (i) Calculate the standard entropy change for the system, $\Delta S^{\ominus}_{\text{system}}$, for this reaction.

Include a sign and units in your answer.

The standard entropy of $BaCl_2.2H_2O(s)$ is +202.9 J K^{-1} mol^{-1}.

Use your Data Booklet for the other values.

(3)

$\Delta S_{system} = \Delta S_{products} - \Delta S_{reactants}$

$BaCl_2 2H_2O + 2(NH_3) - ((Ba(OH)_2) + 2(NH_4Cl))$

$+202.9 + 2 \times 192.3 - (99.7 + 2 \times 94.6)$

$587.5 - 288.9$

$= +298.6$ J mol^{-1} K^{-1}

(ii) Is the sign for the standard entropy change of the system, $\Delta S^{\ominus}_{\text{system}}$, as you would expect? Justify your answer.

(1)

Yes, as for the reaction to be feasible the Δstotal has to be +ve. Δstotal = Δs system + Δs surroundings

(c) (i) The total standard entropy change, $\Delta S^{\ominus}_{total}$, is +227.5 J K⁻¹ mol⁻¹.

Calculate the standard enthalpy change, $\Delta H^{\ominus}$, for this reaction at 298 K.

Include a sign and units in your answer.

(3)

$$+227.5 = +298.6 + \frac{-\Delta H}{298}$$

$$71.1 = \frac{\Delta H}{298}$$

$$\Delta H = +21366.6 \text{ J mol}^{-1}$$

(ii) State and explain how you would expect the temperature to change during this reaction.

(1)

ΔH is positive so it's exothermic. The temperature will increase.

ResultsPlus

Examiner Comments

Part(b)(i) is fine, with the correct value, sign, and units.
Part (b)(ii) is a common incorrect response, confusing total entropy change with entropy change of the system.
In part (c)(i) the wrong standard temperature has been used.
In part (c)(ii) the temperature change is wrong.
Marks 3 0 2 0

ResultsPlus

Examiner Tip

Be careful to read the question.
Remember that changes in enthalpies and entropies refer to the chemicals.

Question 17 (a) (i)

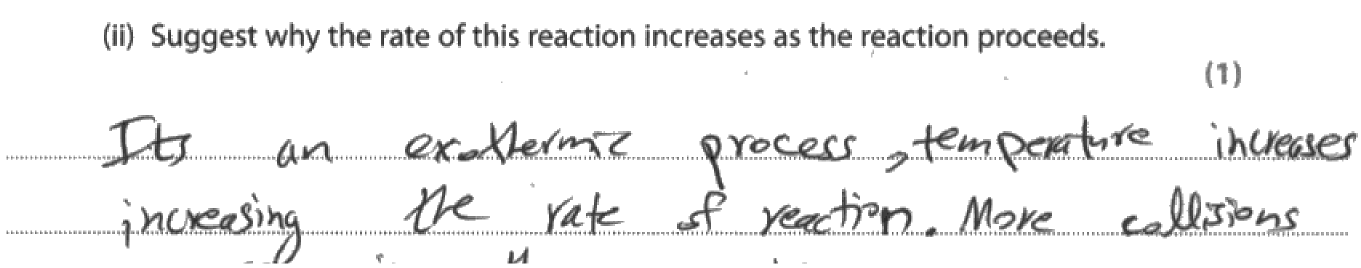
It is surprising that under a quarter of the candidates were able to write the equation for this reaction which is from the specification.

An instructive error was to try to include hydrogen ions on the right side of the equation.

Question 17 (a) (ii)

An even lower proportion of candidates than in part (i) realised that the HI/H^+ formed catalysed the reaction.

Again this is surprising, unless candidates had not done the experiment and looked at the mechanism.



(ii) Suggest why the rate of this reaction increases as the reaction proceeds.

(1)

Its an exothermic process, temperature increases increasing the rate of reaction. More collisions

ResultsPlus
Examiner Tip

The whole purpose of studying this experiment is to find out about the mechanisms.

ResultsPlus
Examiner Comments

This was a common incorrect response.
Mark 0

Question 17 (b) (i)

There was considerable confusion between the reaction under alkaline and acidic conditions.

As a result, incorrect products were often given.

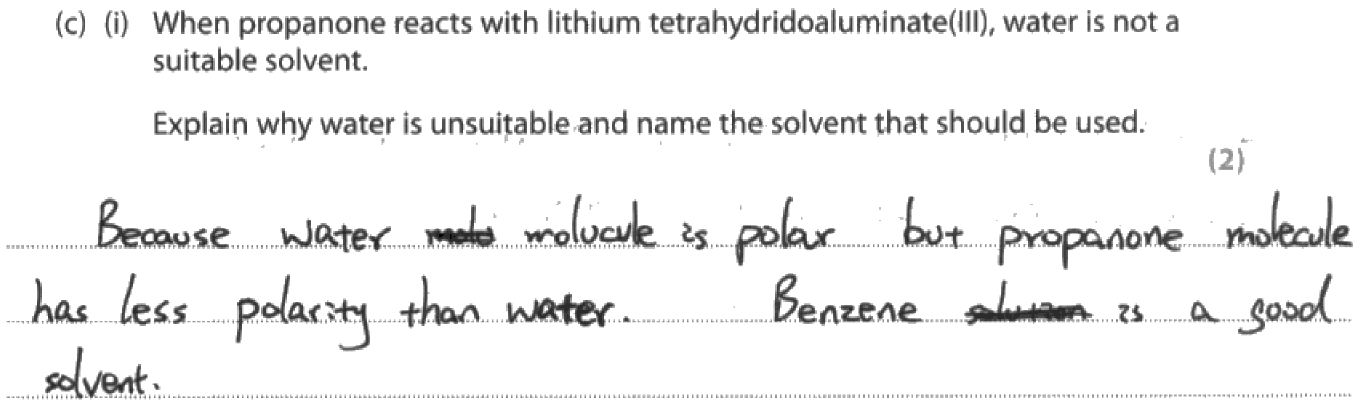
Either the names or the formulae were acceptable, but if both are given they must both be correct.

Question 17 (b) (ii)

Most candidates gave the yellow precipitate but few gave the smell.

Question 17 (c) (i)

Many candidates realised that dry ether should be used but the common incorrect reason was to discuss solubility rather than reactivity with water.



(c) (i) When propanone reacts with lithium tetrahydridoaluminate(III), water is not a suitable solvent.

Explain why water is unsuitable and name the solvent that should be used.

(2)

Because water ~~mole~~ molucule is polar but propanone molecule has less polarity than water. Benzene ~~solution~~ is a good solvent.

ResultsPlus
Examiner Comments

A typical incorrect response about solubility.

On this occasion benzene was suggested as the solvent.
Mark 0

ResultsPlus
Examiner Tip

Learn the conditions for reactions and the reasons for their use.

Question 17 (c) (ii)

This was an easier question. A common error was to put in too many line junctions representing too many carbon atoms.

Question 17 (d) (i)

This was a discriminating question for higher grade candidates.

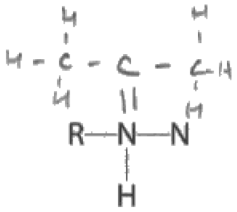
Errors usually involved di, tri or pentavalent carbon atoms.

(d) Propanone reacts with 2,4-dinitrophenylhydrazine to form an organic product which is a crystalline solid and water.

(i) Complete the formula of the crystalline solid.

The formula of 2,4-dinitrophenylhydrazine can be simplified to $RNHNH_2$

(1)



ResultsPlus
Examiner Comments

This has one monovalent nitrogen and one pentavalent nitrogen.
Mark 0

ResultsPlus
Examiner Tip

Remember the basic bonding numbers for carbon nitrogen and oxygen.

Question 17 (d) (ii)

The test for the carbonyl group was often correctly given.

The use to identify a particular aldehyde or ketone was less well known. It is much easier to remember this if you have done this practically.

(ii) What are the **two** uses of 2,4-dinitrophenylhydrazine in the laboratory?

(2)

uses to identify compounds by dissolving them in it then measuring the melting temperature of the solid.

ResultsPlus
Examiner Comments

This was just sufficient for the second mark, but the first point of use to identify aldehydes and ketones has been missed.
Marks 1

ResultsPlus
Examiner Tip

Always learn uses of organic reactions.

Question 17 (e) (i)

Common errors were not displaying the OH or CN bonds.

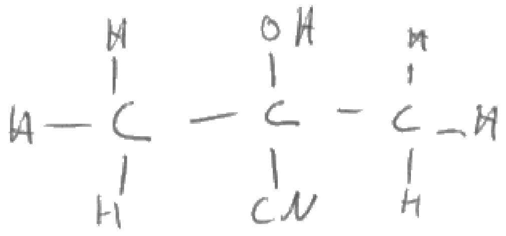
The systematic name was not well known. 'Near misses' often omitted one of the attached groups.

(e) (i) Propanone reacts with hydrogen cyanide to form a cyanohydrin, with structural formula $(CH_3)_2C(OH)CN$.

Give the fully displayed formula and the systematic name for this compound.

(2)

Fully displayed formula



Systematic name 2-hydroxypropan-2-nitrile.

ResultsPlus
Examiner Comments

This response illustrates both the common errors: neither OH nor CN bonds are shown, and the name omits '2- methyl'.
Marks 0

ResultsPlus
Examiner Tip

Learn displayed, structural and skeletal formulae with systematic names for all products of reactions in the specification.

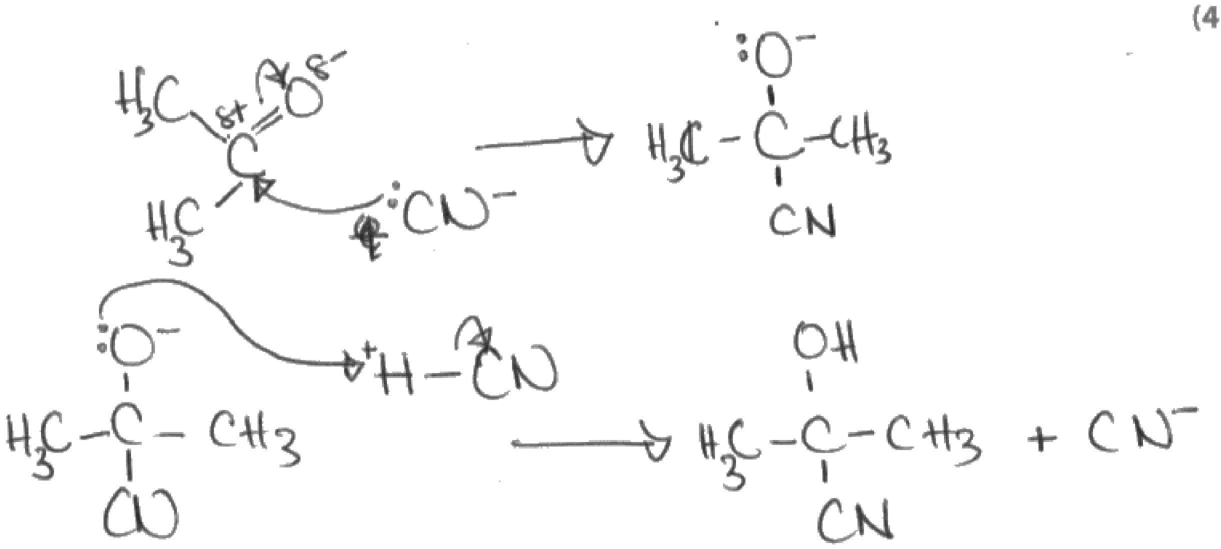
Question 17 (e) (ii)

Common errors were:

- to omit the charge on the cyanide group;
- to start the C=O bond curly arrow on the carbon;
- to omit the charge on the oxygen in the intermediate;
- to attempt to make a bond to an H^+ in the final step, which does not exist to any extent in a solution rich in cyanide ions.

(ii) Draw the mechanism for the reaction of propanone with hydrogen cyanide, in the presence of cyanide ions, to form the cyanohydrin, $(CH_3)_2C(OH)CN$. Use curly arrows to show the movement of electron pairs.

(4)



ResultsPlus

Examiner Comments

This would be fine without the charge on the hydrogen of HCN.
Marks 3

ResultsPlus

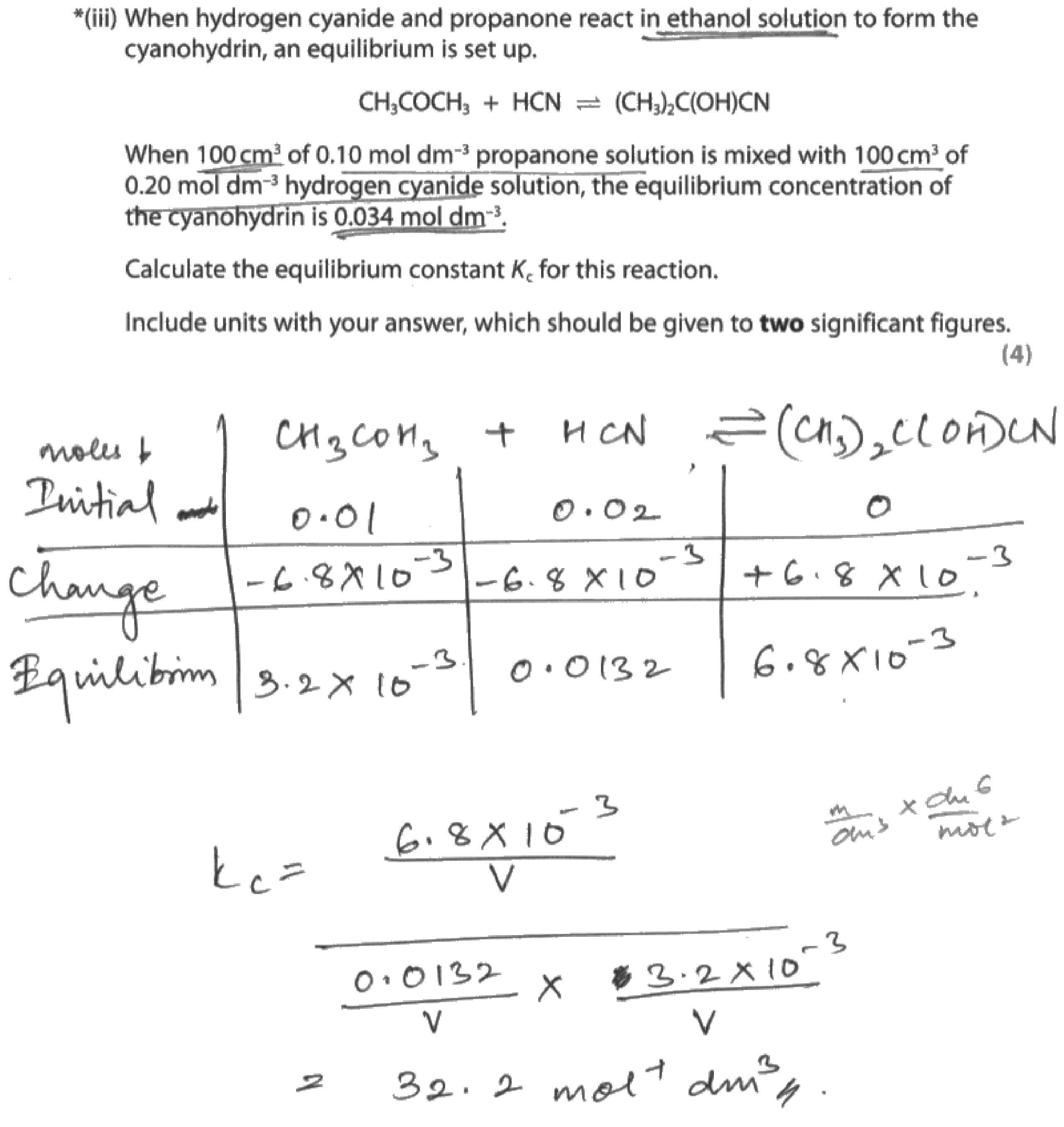
Examiner Tip

Learn the detail of this mechanism.

Question 17 (e) (iii)

There were two methods of answering this question: either start by finding initial concentrations of reactants and products, or by finding initial amounts of reactants and products.

Both are equally valid, though the first is slightly easier, and was more popular.



*(iii) When hydrogen cyanide and propanone react in ethanol solution to form the cyanohydrin, an equilibrium is set up.

$$CH_3COCH_3 + HCN \rightleftharpoons (CH_3)_2C(OH)CN$$

When 100 cm³ of 0.10 mol dm⁻³ propanone solution is mixed with 100 cm³ of 0.20 mol dm⁻³ hydrogen cyanide solution, the equilibrium concentration of the cyanohydrin is 0.034 mol dm⁻³.

Calculate the equilibrium constant K_c for this reaction.

Include units with your answer, which should be given to **two** significant figures.

(4)

moles +	CH_3COH_3 +	HCN ⇌	$(CH_3)_2C(OH)CN$
Initial	0·01	0·02	0
Change	-6.8×10^{-3}	-6.8×10^{-3}	$+6.8 \times 10^{-3}$
Equilibrim	3.2×10^{-3}	0·0132	6.8×10^{-3}

$$\frac{m}{dm^3} \times \frac{dm^6}{mol^2}$$

$$K_c = \frac{\frac{6.8 \times 10^{-3}}{V}}{\frac{0.0132}{V} \times \frac{3.2 \times 10^{-3}}{V}}$$

$$= 32.2 \text{ mol}^{-1} \text{ dm}^3$$

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Examiner Comments

This is an instructive example.

This method is the most popular for solving this type of equilibrium problem.
Calculate initial amounts, changes, equilibrium amounts but the final step is then missed. Calculate the equilibrium concentrations.
The candidate has done this, but not made it totally clear, and might be penalised for this in future.
They have failed to reduce their answer to three significant figures, so lost the final mark.
Marks 3

ResultsPlus

Examiner Tip

Learn this sequence for answering equilibrium questions.

*(iii) When hydrogen cyanide and propanone react in ethanol solution to form the cyanohydrin, an equilibrium is set up.

$$CH_3COCH_3 + HCN \rightleftharpoons (CH_3)_2C(OH)CN$$

When 100 cm³ of 0.10 mol dm⁻³ propanone solution is mixed with 100 cm³ of 0.20 mol dm⁻³ hydrogen cyanide solution, the equilibrium concentration of the cyanohydrin is 0.034 mol dm⁻³.

Calculate the equilibrium constant K_c for this reaction.

Include units with your answer, which should be given to **two** significant figures.

(4)

$$K_c = \frac{[(CH_3)_2C(OH)CN]}{[CH_3COCH_3][HCN]}$$

$$\text{mol of propanone} = \frac{100 \times 0{\cdot}10}{1000} = 0{\cdot}01 \text{ mol}$$

$$\text{mol of hydrogen cyanide} = \frac{100 \times 0{\cdot}20}{1000} = 0{\cdot}02 \text{ mol}$$

~~concentration~~ $[\text{propanone}]_{\text{equilibrium}} = \dfrac{0{\cdot}01}{\frac{200}{1000}} = 0{\cdot}05 \text{ mol dm}^{-3}$

$[\text{hydrogen cyanide}]_{\text{equilibrium}} = \dfrac{0{\cdot}02}{\frac{200}{1000}} = 0{\cdot}1 \text{ mol dm}^{-3}$

$$K_c = \frac{0{\cdot}034}{(0{\cdot}05)(0{\cdot}1)}$$

$$= 6{\cdot}8 \text{ dm}^3 \text{ mol}^{-1}$$

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Examiner Comments

The candidate has only gained the first and the last marks.
They have calculated the correct initial amounts and the correct initial concentrations. They have used these in the expression for the equilibrium constant, but they have done the calculation to two significant figures and given the correct unit.
Marks 2

ResultsPlus

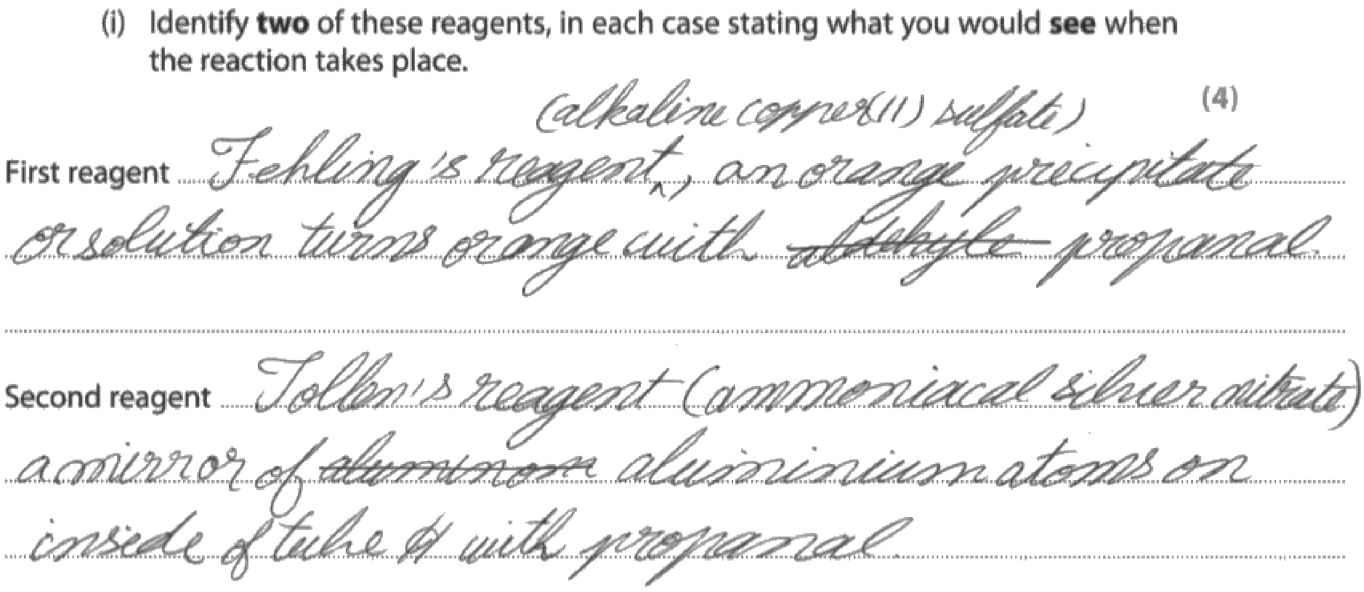
Examiner Tip

Learn the sequence in the first example and practise it on questions.

Question 18 (a) (i)

This was an easier question where pass grade candidates could pick up four marks.

Common errors were to muddle Brady's reagent and Benedict's reagent, to omit the state of the red precipitate, or to give acidified potassium manganate(VII) (which would oxidise many other functional groups.)



(i) Identify **two** of these reagents, in each case stating what you would **see** when the reaction takes place.

(4)

First reagent Fehling's reagent (alkaline copper(II) sulfate), an orange precipitate or solution turns orange with ~~aldehyde~~ propanal

Second reagent Tollen's reagent (ammoniacal silver nitrate) a mirror of ~~aluminum~~ aluminium atoms on inside of tube & with propanal

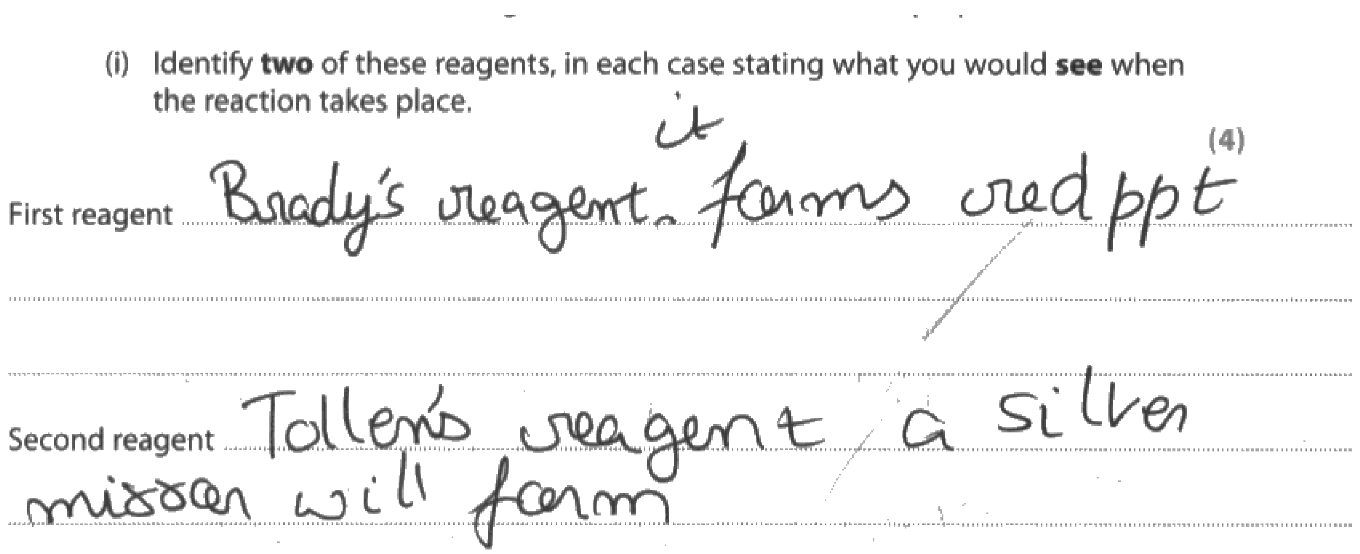
ResultsPlus
Examiner Comments

The reagents are fine.

The observations are both wrong.
Marks 2

ResultsPlus
Examiner Tip

Remember red precipitate is copper(I) oxide.
Silver mirror forms with Tollens' reagent.



(i) Identify **two** of these reagents, in each case stating what you would **see** when the reaction takes place.

(4)

First reagent Brady's reagent. it forms red ppt

Second reagent Tollen's reagent a silver mirror will form

ResultsPlus
Examiner Comments

The first reagent is incorrect and loses both marks.
The second is fine.
Marks 2

ResultsPlus
Examiner Tip

Brady's reagent gives a yellow precipitate and works with both types of carbonyl compound.

Question 18 (a) (ii)

The type of organic reaction refers to the process carried out on the reacting organic chemical.

So here it is oxidation, though redox was allowed on this occasion.

The common error was to give 'reduction'.

Question 18 (b) (i)

Only just over half the candidates were able to do this.

The common error was to give other formulae types.

(b) Propanoic acid can be formed in the reactions in (a).

(i) Give the structural formula of propanoic acid.

(1)

ResultsPlus

Examiner Comments

This is doubly incorrect. It is propan-1-ol, and it is a skeletal formula!
Mark 0

ResultsPlus

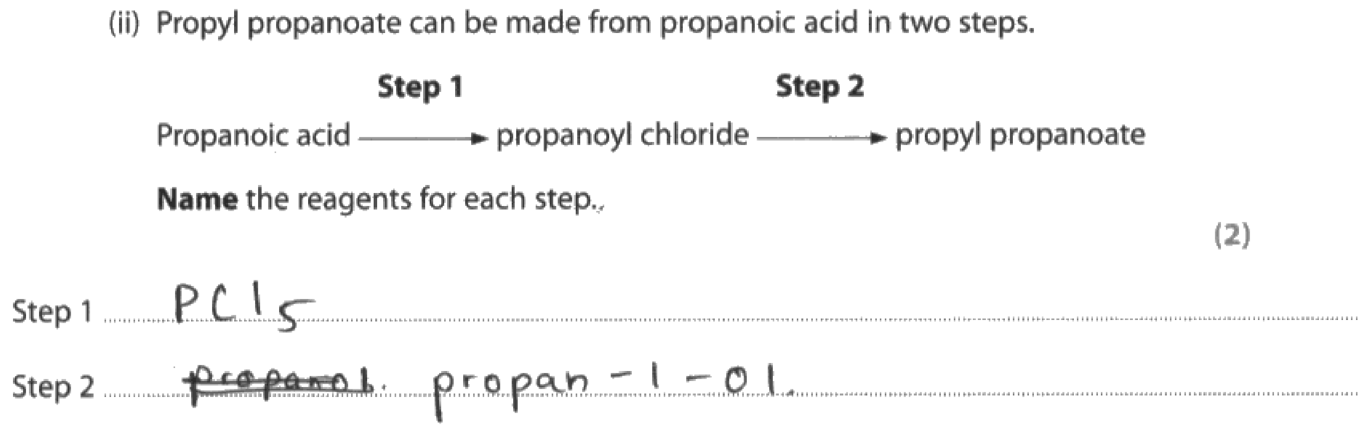
Examiner Tip

Practise writing the different formulae types for the organic products of the reaction in the specification.

Question 18 (b) (ii)

Despite ‘**Name**’ in bold the common error was to give ‘PCl_5’.

Many gave ‘propanol’ which could be more than one chemical.



(ii) Propyl propanoate can be made from propanoic acid in two steps.

$$\text{Propanoic acid} \xrightarrow{\textbf{Step 1}} \text{propanoyl chloride} \xrightarrow{\textbf{Step 2}} \text{propyl propanoate}$$

Name the reagents for each step.

(2)

Step 1 PCl_5

Step 2 ~~propanol~~. propan-1-ol.

ResultsPlus

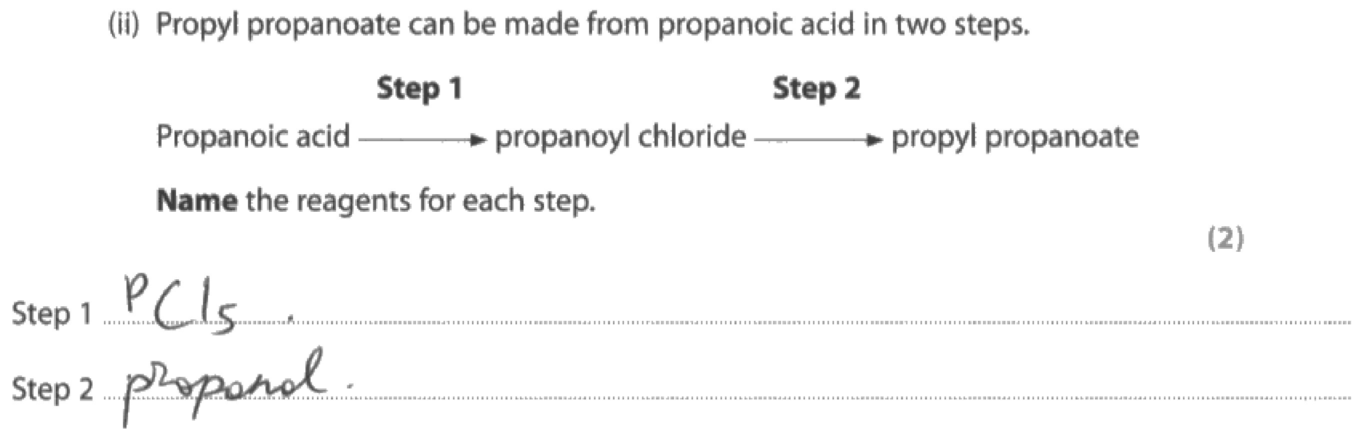
Examiner Comments

The most common error, failing to name the first reagent.
The second is correct.
Mark 1

ResultsPlus

Examiner Tip

Read the question at least twice.



(ii) Propyl propanoate can be made from propanoic acid in two steps.

$$\text{Propanoic acid} \xrightarrow{\textbf{Step 1}} \text{propanoyl chloride} \xrightarrow{\textbf{Step 2}} \text{propyl propanoate}$$

Name the reagents for each step.

(2)

Step 1 PCl_5.

Step 2 propanol.

ResultsPlus

Examiner Comments

Both the common errors.
Mark 0

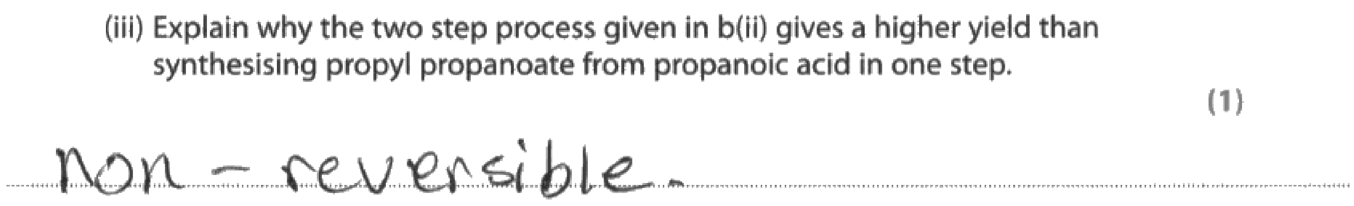
ResultsPlus

Examiner Tip

After answering a question, go back and check the question again to ensure you have answered it correctly and as fully as possible.

Question 18 (b) (iii)

This was a simple, but discriminating, question for high grade candidates.



(iii) Explain why the two step process given in b(ii) gives a higher yield than synthesising propyl propanoate from propanoic acid in one step.

(1)

non - reversible.

ResultsPlus

Examiner Comments

This was the common insufficient response. It is true, but not as precise as ‘not an equilibrium reaction’ or even better ‘the reaction goes to completion’.

Mark 0

ResultsPlus

Examiner Tip

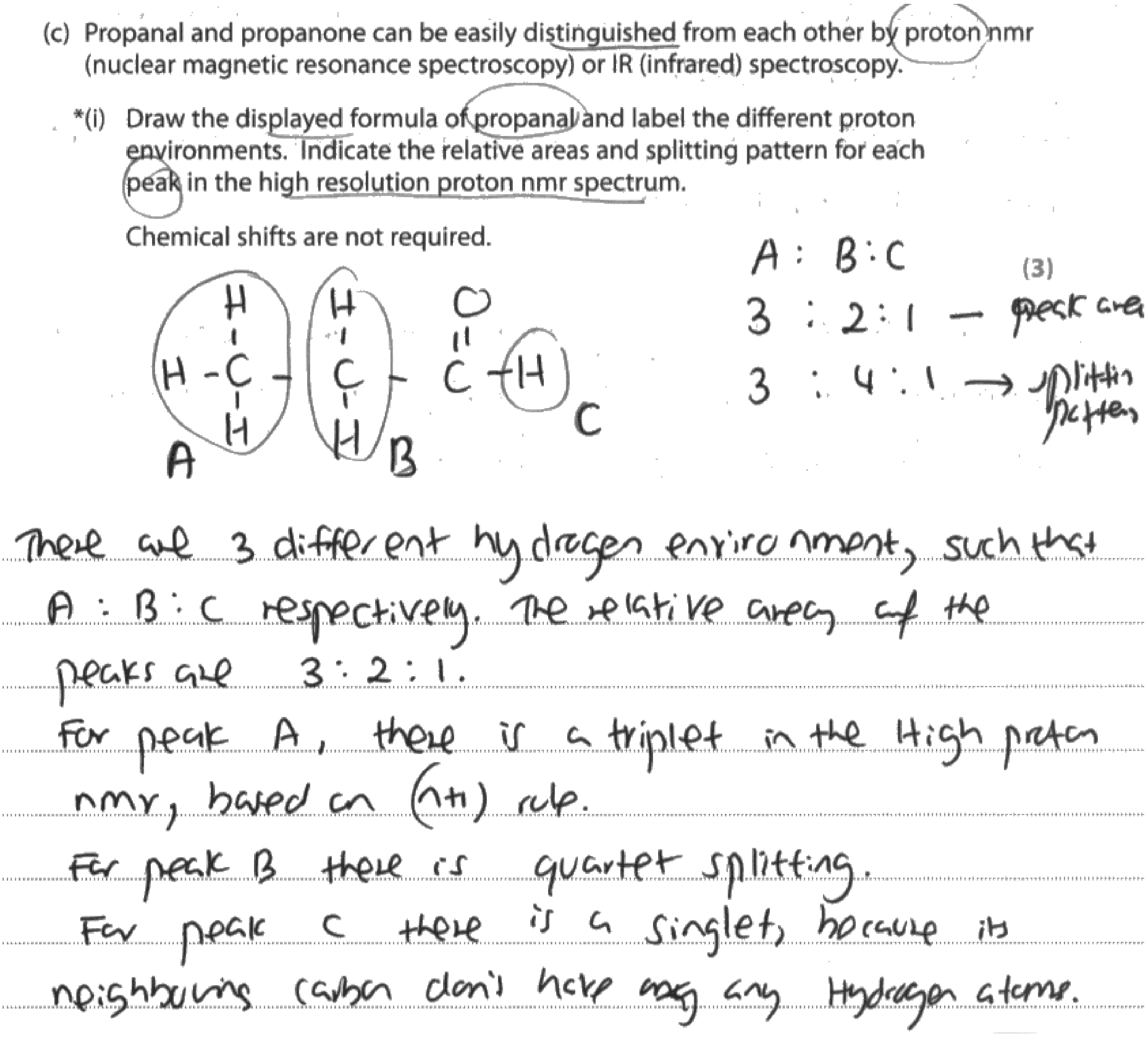
Always try to answer each question as fully as possible.

Question 18 (c) (i)

The modal mark on this item was two.

There were three common errors.

The first was the spitting of the CH_2 hydrogen peak. The second was the splitting of the aldehydic hydrogen peak. The third was to get everything correct apart from failing to give any areas at all.



(c) Propanal and propanone can be easily distinguished from each other by proton nmr (nuclear magnetic resonance spectroscopy) or IR (infrared) spectroscopy.

*(i) Draw the displayed formula of propanal and label the different proton environments. Indicate the relative areas and splitting pattern for each peak in the high resolution proton nmr spectrum.

Chemical shifts are not required.

(3)

A : B : C

3 : 2 : 1 — peak area

3 : 4 : 1 → splitting pattern

There are 3 different hydrogen environment, such that A : B : C respectively. The relative areas of the peaks are 3 : 2 : 1.

For peak A, there is a triplet in the High proton nmr, based on (n+1) rule.

For peak B there is quartet splitting.

For peak C there is a singlet, because its neighbouring carbon don't have ~~any~~ any Hydrogen atoms.

ResultsPlus

Examiner Comments

This is an instructive two-mark response.
It is well set out, clearly showing the three hydrogen environments give rise to three peaks.
Their three relative areas are clear too.
The only errors are the splitting of the CH_2 hydrogen peak, and the singlet for the aldehydic hydrogen peak.
Marks 2

ResultsPlus

Examiner Tip

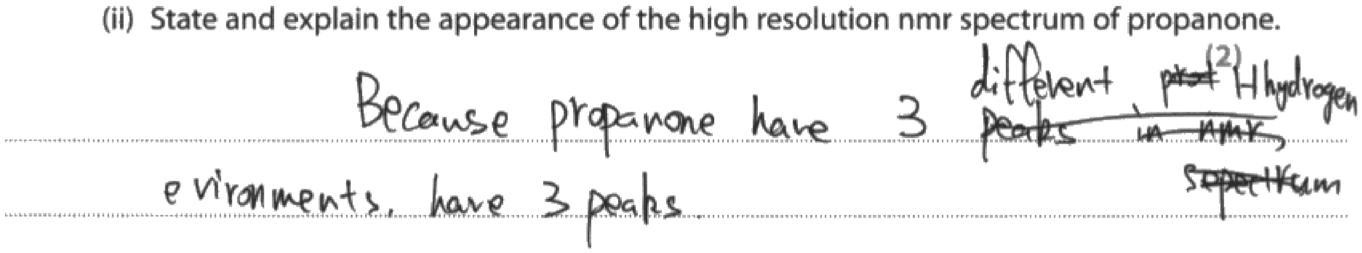
For splitting, count up the number of hydrogens on adjacent carbon atoms and add one.

Question 18 (c) (ii)

There was no transferred error for the incorrect number of peaks.

Identical hydrogen environments give one peak.

The common error was to give a ‘singlet’ without the word ‘peak’, when the second mark for only one hydrogen environment could still be scored.



(ii) State and explain the appearance of the high resolution nmr spectrum of propanone.

(2)

Because propanone have 3 ~~peaks~~ different ~~prot~~ H hydrogen ~~in nmr~~, ~~spectrum~~ evironments, have 3 peaks.

ResultsPlus

Examiner Comments

There was no transferred error for the incorrect number of peaks.
Mark 0

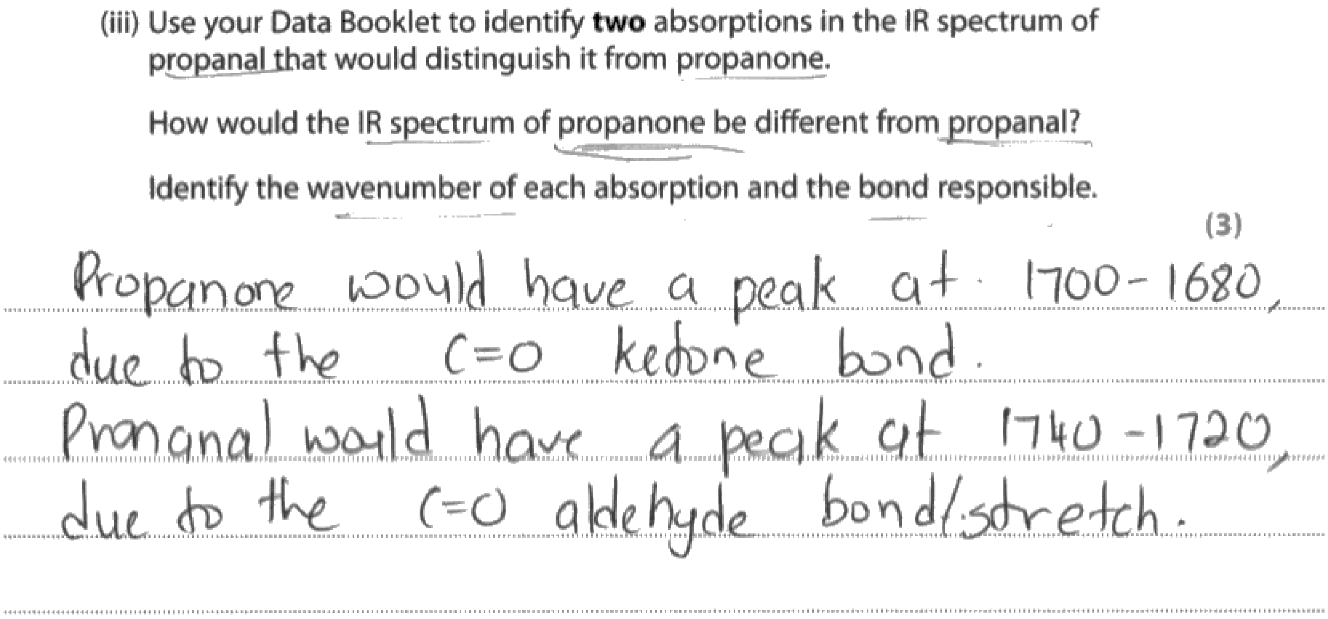
ResultsPlus

Examiner Tip

Identical hydrogen environments give one peak.

Question 18 (c) (iii)

Most candidates found the C = O bond data correctly. In weaker responses they failed to give the compound type or the bond, and just gave the wave number values, which scored 1 mark only. The best responses gave the aldehyde C – H stretching absorption for the third mark.



(iii) Use your Data Booklet to identify **two** absorptions in the IR spectrum of propanal that would distinguish it from propanone.

How would the IR spectrum of propanone be different from propanal?

Identify the wavenumber of each absorption and the bond responsible.

(3)

Propanone would have a peak at 1700-1680, due to the C=O ketone bond.
Pronanal would have a peak at 1740-1720, due to the C=O aldehyde bond/stretch.

ResultsPlus
Examiner Comments

A typical two-mark response.

ResultsPlus
Examiner Tip

The aldehyde C-H stretching absorption is a much better indication of an aldehyde compared to a ketone as the other values are so close in the IR spectrum.

Question 19 (a)

This question illustrated the problems candidates have in reading axes on graphs and their units.

In weaker responses, candidates failed to choose a sensible scale:

10 small squares = 0.05 mol dm^{-3} on the y (vertical) axis was best.

They also omitted the square brackets representing ‘concentration of’ around the hydrogen peroxide, and/or the t/10^3 s on the x (horizontal) axis.

In plotting, the last point was most commonly plotted in the wrong place, or omitted altogether.

Lines were correctly drawn to find the half-lives, but the intercept values were often incorrectly read.

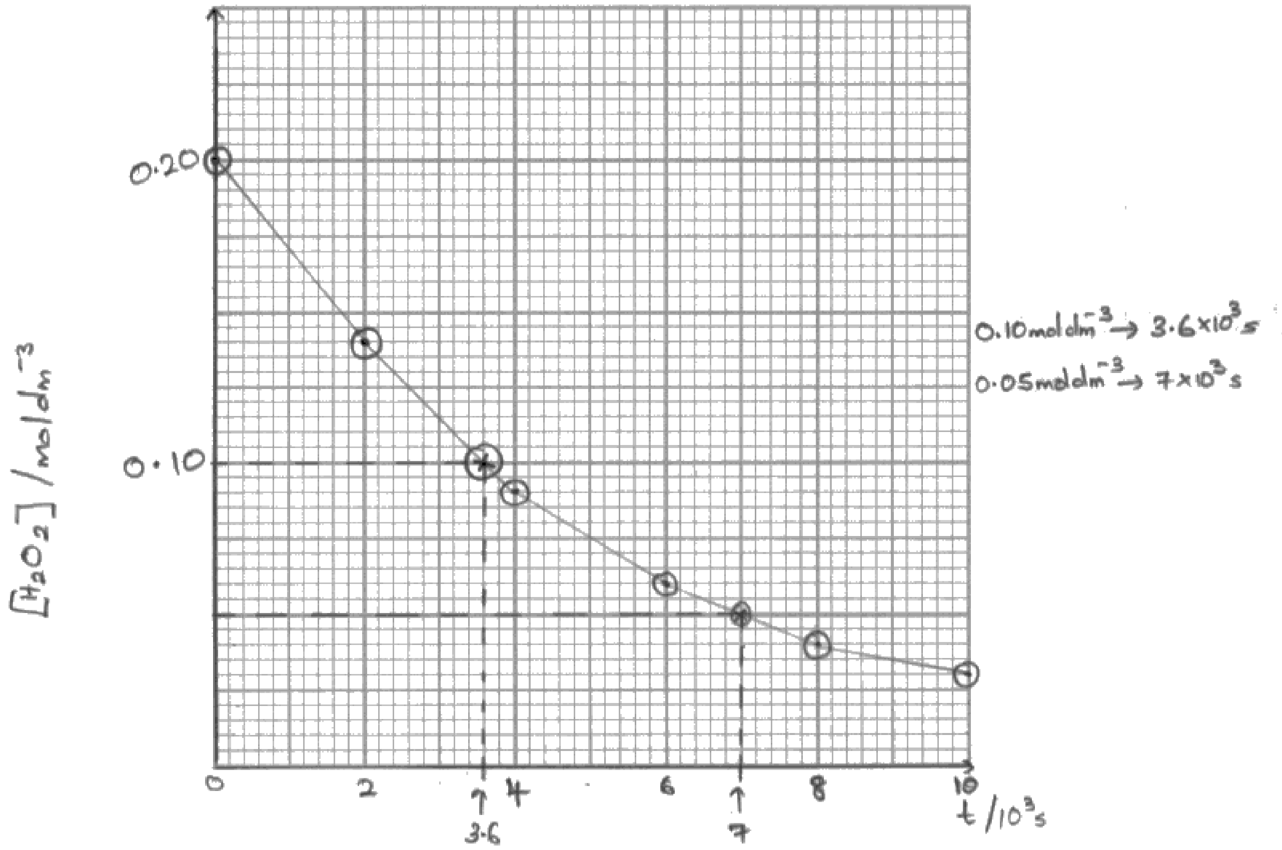
Finding the second half-life, which involves subtracting the first intercept value from the second just did not happen.

Then the units were usually ignored, so the factor of 1000 was lost.

Candidates usually ignored their values and recalled ‘first order because half-lives are constant’ to gain the last two marks. In future examiners may insist on a deduction based on their values.

(i) Plot a graph of $[H_2O_2]$ / mol dm^{-3} against t / 10^3 s.

(2)



0.10 mol dm^{-3} → 3.6×10^3 s

0.05 mol dm^{-3} → 7×10^3 s

(ii) Find **two** successive half-lives from your graph.

Show your working on your graph, together with their values.

(2)

(iii) Deduce the order of the reaction with respect to hydrogen peroxide.

Justify your answer.

(2)

1st order reaction as the gradient of the graph is positive

ResultsPlus

Examiner Comments

The presentation of the graph and half-lives is excellent.

The points are carefully and clearly plotted, and the curve is smoothly drawn.
No subtraction has been carried out for the second half-life.
The order is correct but the reason is wrong.
Marks 2 1 1

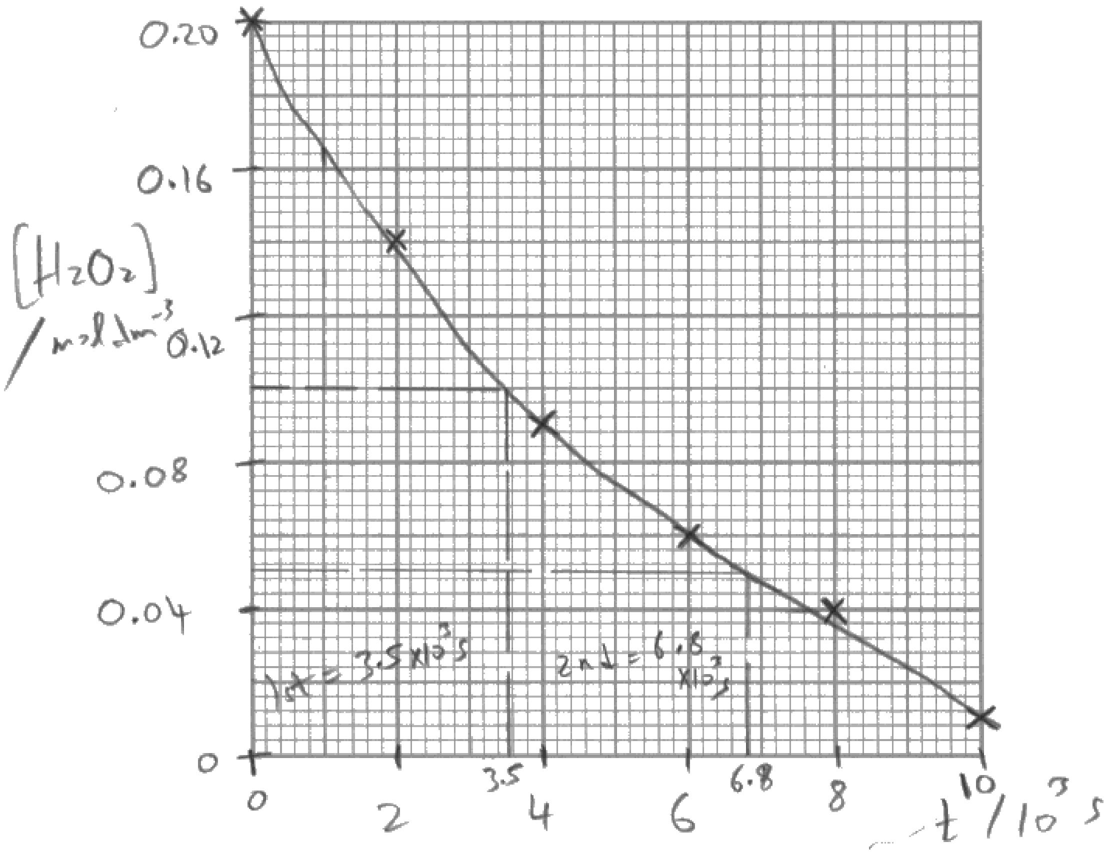
ResultsPlus

Examiner Tip

Practice drawing smooth curves – the trick is to look at the next point and not your pen as you draw.

(i) Plot a graph of [H_2O_2] / mol dm^{-3} against t / 10^3 s.

(2)



(ii) Find **two** successive half-lives from your graph.

Show your working on your graph, together with their values.

1st = 3.5 x10^3 s   2nd = 6.8 x10^3 s

(2)

(iii) Deduce the order of the reaction with respect to hydrogen peroxide.

Justify your answer.

(2)

Its first order with respect to hydrogen peroxide.
Concentration is directly proportional to time.
1st & second half lives are almost same.

ResultsPlus
Examiner Comments

There is a clear plotting error for the last point in the graph.
No subtraction has been carried out for the second half-life.
The order is correct but the additional reason is wrong.
So this is 2 -1 = 1 mark.
Marks 1 1 1

ResultsPlus
Examiner Tip

Make sure any additional information is correct.

Question 19 (b) (i)

The common instructive error here was to fail to give the clear relationship between the volume and concentration as a proportionality.

Question 19 (b) (ii)

The key point here is that the reaction rate is constant *during the time of the measurement.*

The 'near miss' omitted the last phrase.

Question 19 (b) (iii-vi)

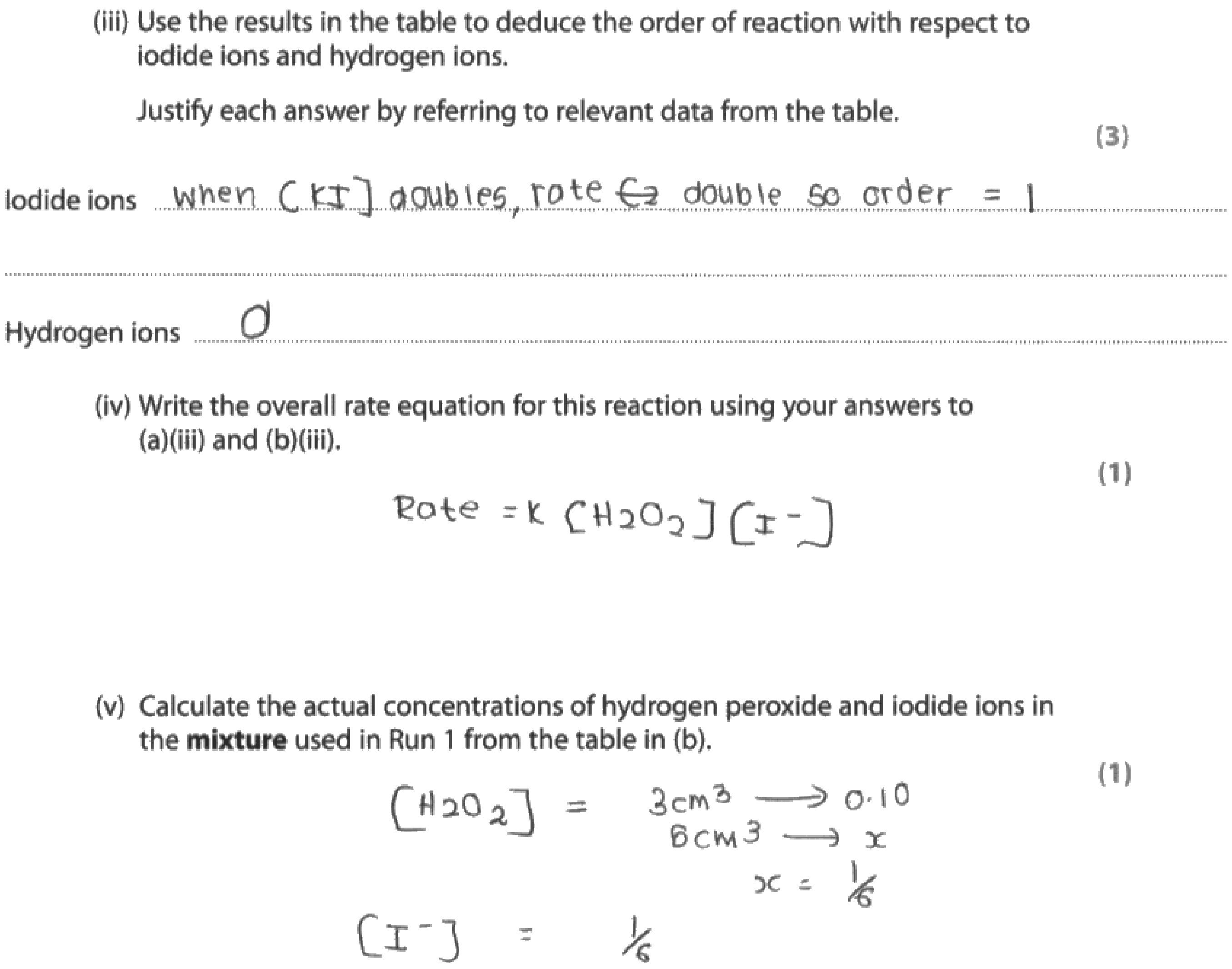
Many weaker candidates could not handle this data.

They should be familiar with this type of data from carrying out at least one 'clock' type experiment and processing the results.

Some could correctly deduce the orders but gave inadequate explanations.

Rate expressions were usually consistent with reaction orders but weak candidates often omitted the rate constant.

Transferred errors (TE) were allowed in part (vi). The unit mark was available even if the value was incorrect.



(iii) Use the results in the table to deduce the order of reaction with respect to iodide ions and hydrogen ions.

Justify each answer by referring to relevant data from the table.

(3)

Iodide ions when [KI] doubles, rate double so order = 1

Hydrogen ions 0

(iv) Write the overall rate equation for this reaction using your answers to (a)(iii) and (b)(iii).

(1)

$$\text{Rate} = k[H_2O_2][I^-]$$

(v) Calculate the actual concentrations of hydrogen peroxide and iodide ions in the **mixture** used in Run 1 from the table in (b).

(1)

$$[H_2O_2] = \begin{array}{l} 3\,cm^3 \longrightarrow 0.10 \\ 8\,cm^3 \longrightarrow x \\ x = \frac{1}{6} \end{array}$$

$$[I^-] = \frac{1}{6}$$

(vi) Calculate a value for the rate constant using Run 1 from the table in (b) and your answers to parts (b)(iv) and (b)(v). Include units for the rate constant.

(2)

~~Rate = $k[H_2O_2][KI]$~~

Rate $= k\,[H_2O_2]\,[I^-]$

$$\frac{1.06 \times 10^{-4}}{\frac{1}{6} \times \frac{1}{6}} = k$$

$k = 3.816 \times 10^{-3}$ $mol^{-1}\,dm^{3}\,s^{-1}$

ResultsPlus

Examiner Comments

In part (iii) the orders are correct. The iodide reason is just sufficient and the rate equation is fine.
The concentrations are incorrect, but there is a fully correct TE and correct unit in part (vi).
Marks 2 1 0 2

ResultsPlus

Examiner Tip

Practise these types of question.

(iii) Use the results in the table to deduce the order of reaction with respect to iodide ions and hydrogen ions.

Justify each answer by referring to relevant data from the table.

(3)

Iodide ions Run ① and ② when $[H_2O_2]$ and $(H_2SO_4]$ are kept constant. The o.w.r.t I^- is 1st order.

Hydrogen ions Run ④ and ⑤ when $(KI]$ and $[H_2O_2]$ is kept constand. O.w.r.t H^+ is. 1st order

(iv) Write the overall rate equation for this reaction using your answers to (a)(iii) and (b)(iii).

(1)

Rate = k $[H_2O_2][H^+][I^-]$.

(v) Calculate the actual concentrations of hydrogen peroxide and iodide ions in the **mixture** used in Run 1 from the table in (b).

(1)

~~R~~ ~~1.06×10^{-4}~~ 0.025 mol dm^{-3}.

~~1.5 mol dm^{-3} and 1~~

(vi) Calculate a value for the rate constant using Run 1 from the table in (b) and your answers to parts (b)(iv) and (b)(v). Include units for the rate constant.

(2)

Rate = k $[H_2O_2][H^+][I^-]$.

$$\frac{1.06 \times 10^{-4}}{(0.025)^3} = k$$

~~k~~ ~~m~~×m×n mol^{2}dm^{-3}

6.784 = k

6.784 mol^{-2}dm^{6}s^{-1} = k

~~3~~ 0.10 m — 1 m 12 cm^3

in 3 cm^3.

0.3 — In 12 cm^3

In 3 cm^3

ResultsPlus

Examiner Comments

Both reasons are insufficient in part (iii).

There is a TE from (a) allowed in parts (iv) and (vi). Notice the correct TE unit in part (vi).

Marks 1 1 1 2

ResultsPlus

Examiner Tip

It is always best to keep going if you make a mistake.

Question 19 (c) (i)

This was a different type of activation energy calculation as the plotted graph of ln(rate) against reciprocal temperature was given.

Notice this has the same slope as the ln(rate constant) graph, just a different intercept.

Once again, the problem was reading of coordinates of points accurately.

A high tolerance was allowed on this occasion, but this may not be the case in future papers.

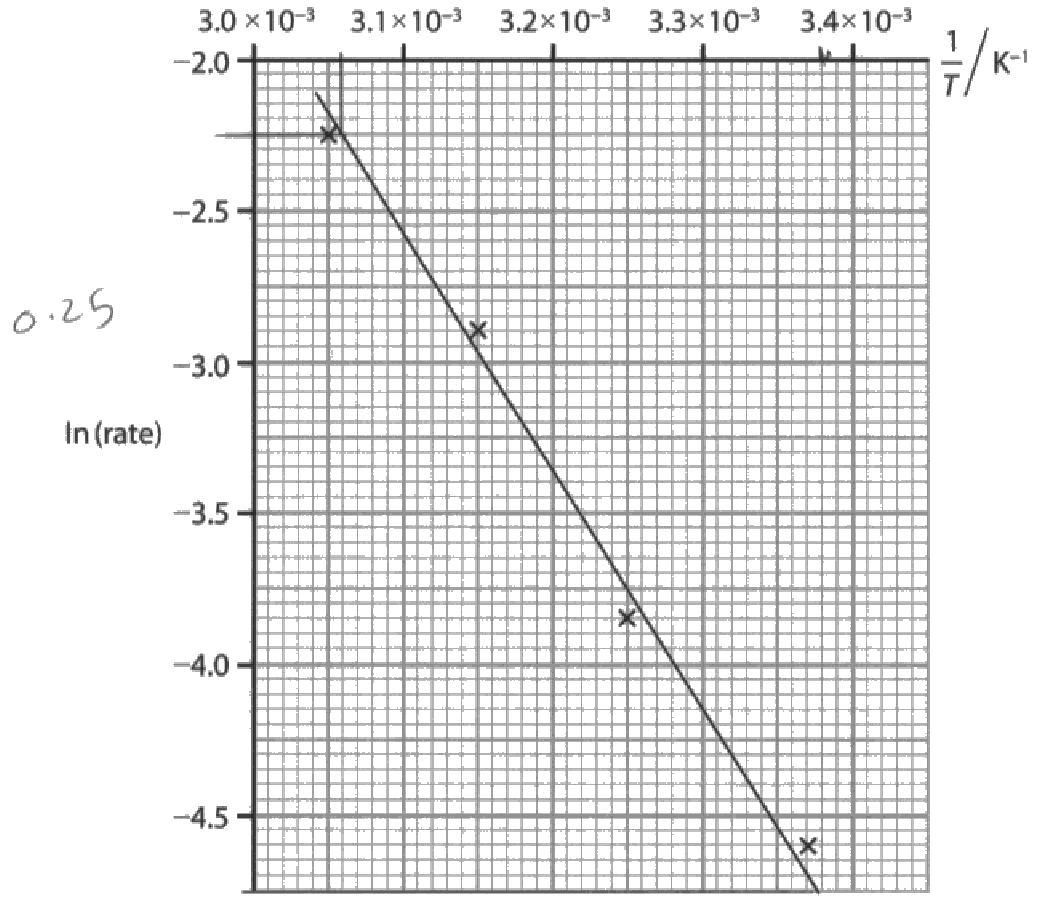
In some weak responses candidates did not find a gradient, using the expression upside down.

In moderate responses they omitted the negative sign which was penalised – the question clearly stated ‘Calculate the gradient’.

Both positive and negative answers were allowed, provided a sign was included.

(c) (i) The activation energy for this reaction is found by keeping the concentrations of reactants constant and repeating the reaction at different temperatures.

A graph of ln(rate) of the reaction against reciprocal of temperature is given below.



Calculate the gradient of the graph.

Use your value of the gradient and the equation below to calculate the activation energy of the reaction.

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

Include a sign and units with your answer.

(3)

$$\text{gradient} = \frac{-2.75 - -4.25}{3.38\times10^{-3} - 3.6\times10^{-3}} = -6818$$

$$y = mx + c$$

$$\ln \text{rate} = \frac{Ea}{R} \times \frac{1}{T} + \text{constant}$$

$$\text{gradient} = \frac{Ea}{R} \qquad Ea = -56659$$

or 56659

ResultsPlus

Examiner Comments

First x (horizontal) axis reading 3.6×10^{-3} is incorrect - should be 3.12×10^{-3}, so gradient well out of range.
Second mark given for multiplying by 8.31 correct TE.
No third mark as no unit.
Marks 1

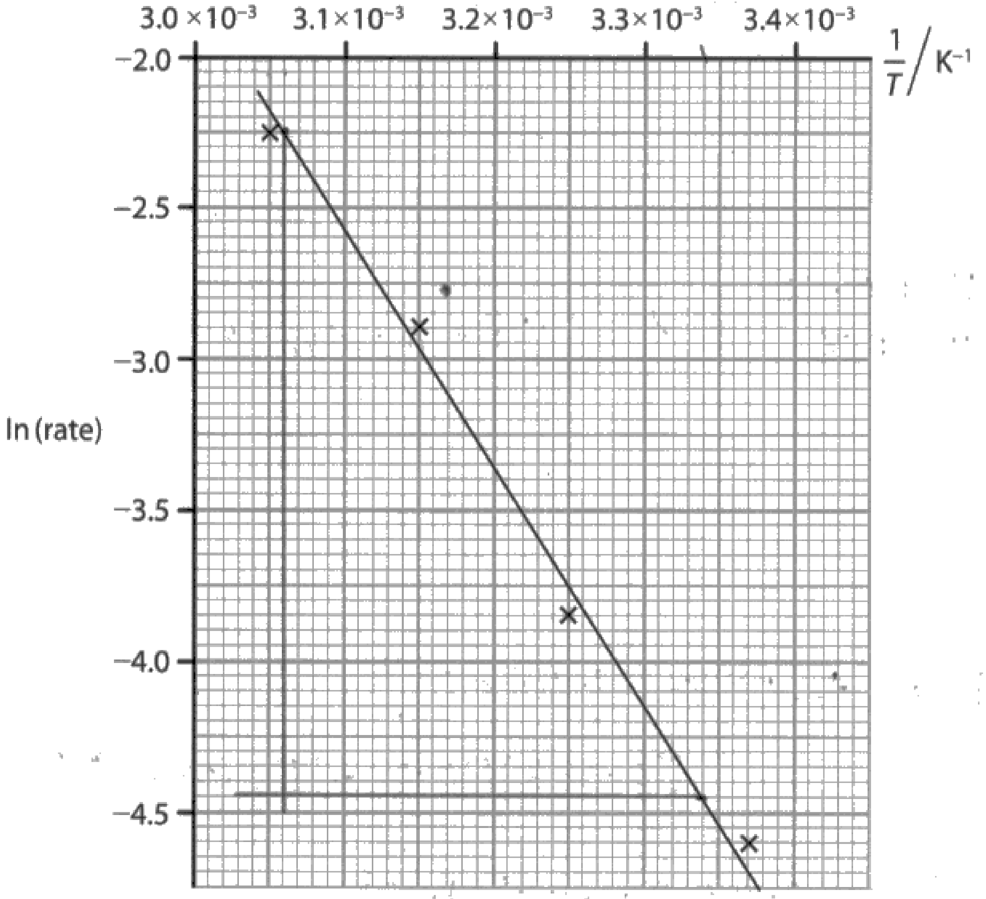
ResultsPlus

Examiner Tip

Use a ruler to check axis readings are correct.

(c) (i) The activation energy for this reaction is found by keeping the concentrations of reactants constant and repeating the reaction at different temperatures.

A graph of ln(rate) of the reaction against reciprocal of temperature is given below.



Calculate the gradient of the graph.

Use your value of the gradient and the equation below to calculate the activation energy of the reaction.

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

Include a sign and units with your answer.

(3)

$(\overset{x_1}{3.06\times10^{-3}}, \overset{y_1}{2.25})$ $(\overset{x_2}{3.34\times10^{-3}}, \overset{y_2}{4.25})$

$$\frac{y_2-y_1}{x_2-x_1} = \frac{4.25-2.25}{3.34\times10^{-3}-3.06\times10^{-3}} = 7142.86$$

gradient = $\frac{Ea}{R}$

$7142.86 \times (8.31) = Ea$

$Ea = 59357\ J$

~~≈ +59.4 kJ~~

≈ +59.4 kJ

ResultsPlus

Examiner Comments

The negative sign is missing from the y (vertical) axis coordinates, so the sign is incorrect.
Also the x (horizontal) axis for the first point has been read incorrectly – it should be 3.31 x 10^{-3} so the gradient is out of tolerance as well.
However, these two errors only lose first marking point.
Second mark given for multiplying by 8.31 and correct TE.
Part of unit missing so no third mark.
Marks 1

ResultsPlus

Examiner Tip

Check each reading from a graph carefully, including the units.

Question 19 (c) (ii)

Though first covered in Unit 2, this work is examinable in Unit 4 as well.

The most common mark on this part was zero, though the mean for the question was just over half the marks.

Candidates had problems in first selecting the correct graph – an energy profile during a reaction was often drawn.

Those who chose correctly often had trouble with axis labels, either getting them the wrong way round, or struggling with the y (vertical) axis.

Many curves did not start at zero or cut the x (horizontal) axis or rose upwards at the end.

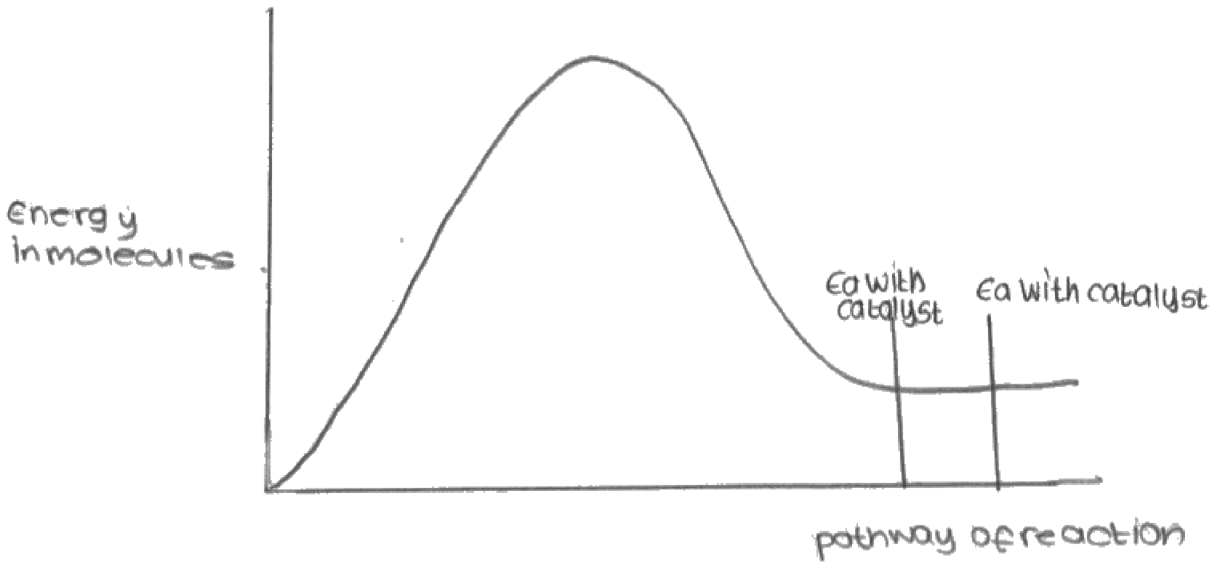
Many candidates gained credit for the final marking point.

*(ii) If the same reaction is carried out in the presence of a catalyst of ammonium molybdate, the activation energy is found to be much lower.

Sketch a Maxwell-Boltzmann distribution of molecular energies.

Use your sketch to explain why this reduction in activation energy increases the rate of the reaction.

(3)



Explanation

It ~~is~~ increases the rate of reaction because more molecules have energy greater than activation energy so more successful collisions occur.

ResultsPlus

Examiner Comments

The axes are incorrect, confusing this with an energy profile diagram.

The graph is just acceptable starting at zero and flattening out at the end, though it flattens too far from the x (horizontal) axis, which it should approach asymptotically.
The final statement was a common ‘rescue’ mark and received credit whatever had gone before unless there was a clear contradiction.
Marks 2

ResultsPlus

Examiner Tip

Though first covered in Unit 2, this work is examinable in Unit 4 as well.

Paper Summary

Based on their performance on this paper, candidates are offered the following advice:

- Improve their knowledge of practical methods, both in detail of, and in the reasons behind, procedures;
- Practise deducing the significance of the results of practical work;
- Practise drawing and reading values from the various types of graphs involved in this unit;
- Practise equilibrium calculations;
- Practise writing displayed, structural and skeletal formulae of organic reactants and products met in this unit;
- Practise writing equations for all the reactions met in this unit.

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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