Pearson

# Mark Scheme (Results)

# October 2025

Pearson Edexcel International Advanced Level in Chemistry
WCH14/01A

# Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus

## Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

October 2025
Question Paper Log Number P87421A
Publication Code WCH14_01A_2510_MS
All the material in this publication is copyright
© Pearson Education Ltd

## General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

## Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

## Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

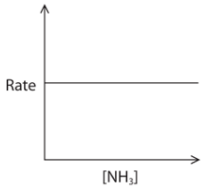
Full marks will be awarded if the candidate has demonstrated the above abilities. Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

**Section A**

| Question Number | Answer | Mark |
|---|---|---|
| 1 | **The only correct answer is B** (electrical conductivity)<br><br>***A*** *is incorrect because none of the reactants or products are coloured*<br><br>***C*** *is incorrect because there is no change in mass*<br><br>***D*** *is incorrect because titration is not a continuous monitoring method* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| 2(a) | **The only correct answer is A** (rate = k)<br><br>***B*** *is incorrect because this is a first order rate equation*<br><br>***C*** *is incorrect because this is a second order rate equation*<br><br>***D*** *is incorrect because this shows overall order four and refers to the reverse reaction* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| 2(b) | **The only correct answer is C** (mol $dm^{-3}$ $s^{-1}$)<br><br>***A*** *is incorrect because rate constants always have units*<br><br>***B*** *is incorrect because these are the units of a first order rate constant*<br><br>***D*** *is incorrect because these are the units of a second order rate constant* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| 2(c) | <br>**The only correct answer is A** ( )<br>***B*** *is incorrect because this graph shows a first order reaction*<br>***C*** *is incorrect because this graph shows a first order reaction*<br>***D*** *is incorrect because this graph shows no reaction occurring* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| 3 | **The only correct answer is D** ($S_N1$ ; two )<br>***A*** *is incorrect because the halogenoalkane is tertiary so the mechanism would be $S_N1$ which has two steps*<br>***B*** *is incorrect because the halogenoalkane is tertiary and so the mechanism would be $S_N1$*<br>***C*** *is incorrect because the $S_N1$ mechanism has two steps* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| 4 | **The only correct answer is C** ( $K_c = \frac{[CO][H_2]}{[H_2O]}$ )<br><br>***A*** *is incorrect because the concentration of steam has been omitted*<br><br>***B*** *is incorrect because the concentration of steam has been omitted and carbon is not in the gas phase*<br><br>***D*** *is incorrect because carbon is not in the gas phase* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| 5 | **The only correct answer is C** ( $CH_2ClCOOH$ and $CH_3COOH_2^+$ )<br><br>***A*** *is incorrect because ethanoic acid accepts a proton in this system so is a base*<br><br>***B*** *is incorrect because ethanoic acid accepts a proton in this system so is a base*<br><br>***D*** *is incorrect because* $CH_2ClCOO^-$ *is a base* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| 6 | **The only correct answer is B** (13.0)<br><br>***A*** *is incorrect because the concentration of hydroxide ions is not 0.20 mol* $dm^{-3}$<br><br>***C*** *is incorrect because the concentration of hydroxide ions is not 0.050 mol* $dm^{-3}$<br><br>***D*** *is incorrect because the concentration of hydroxide ions is not 0.025 mol* $dm^{-3}$ | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| 7 | **The only correct answer is A** (5.06)<br><br>***B*** *is incorrect because this is the pH of an equimolar solution of* $CH_3COOH$ *and* $CH_3COONa$<br><br>***C*** *is incorrect because this is the pH when the concentrations are reversed*<br><br>***D*** *is incorrect because his is the pH of a 0.100 mol* $dm^{-3}$ *solution of* $CH_3COOH$ | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| 8 | **The only correct answer is B** (bromocresol green ($pK_{in} = 4.7$) )<br><br>***A*** *is incorrect because the pH range would not lie within the vertical section of a strong acid and weak base titration*<br><br>***C*** *is incorrect because the pH range would not lie within the vertical section of a strong acid and weak base titration*<br><br>***D*** *is incorrect because the pH range would not lie within the vertical section of a strong acid and weak base titration* | **(1)** |

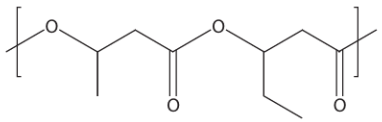
| Question Number | Answer | Mark |
|---|---|---|
| 9(a) | **The only correct answer is C** (the second ionisation energy of strontium is +1614 kJ $mol^{-1}$)<br><br>***A*** *is incorrect because lattice energies are always exothermic*<br><br>***B*** *is incorrect because −590 is twice the first electron affinity of iodine*<br><br>***C*** *is incorrect because the standard enthalpy change of atomisation of strontium is +164 kJ* $mol^{-1}$ | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| 9(b) | **The only correct answer is D** (+107)<br><br>***A*** *is incorrect because the sign of the enthalpy change of atomisation of strontium has not been reversed and the answer has not been divided by two*<br><br>***B*** *is incorrect because the sign of the enthalpy change of atomisation of strontium has not been reversed*<br><br>***C*** *is incorrect because +214 is the enthalpy change in producing 2 mol of I(g)* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| 10(a) | **The only correct answer is B** (retention time)<br><br>***A*** *is incorrect because this term does not relate to gas chromatography*<br><br>***C*** *is incorrect because this term is not used*<br><br>***D*** *is incorrect because this term is not used* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| 10(b) | **The only correct answer is A** (argon)<br><br>***B*** *is incorrect because the carrier gas must be inert*<br><br>***C*** *is incorrect because the carrier gas must be inert*<br><br>***D*** *is incorrect because the carrier gas must be inert* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| 10(c) | **The only correct answer is B** (84 mm)<br><br>***A*** *is incorrect because 840 mm is a factor of 10 too large*<br><br>***C*** *is incorrect because this is the distance moved by the amino acid*<br><br>***D*** *is incorrect because this is the distance moved multiplied by the distance travelled by the amino acid* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| 11 | **The only correct answer is A (**  **)**<br><br>***B*** *is incorrect because there is an extra carbon atom at the left hand end of the repeat unit*<br><br>***C*** *is incorrect because this repeat unit has an extra oxygen and the structure is incorrect*<br><br>***D*** *is incorrect because this repeat unit has an extra oxygen* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| 12 | **The only correct answer is D** ($CH_3COCl$)<br><br>***A*** *is incorrect because the reaction with a ketone would not produce an N-substituted amide*<br><br>***B*** *is incorrect because any reaction with the carboxylic acid would be too slow at room temperature*<br><br>***C*** *is incorrect because any reaction with the ester would be too slow at room temperature* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| **13(a)** | **The only correct answer is C** (**Y** and **Z** only)<br><br>***A*** *is incorrect because neither* ***W*** *nor* ***X*** *are methyl ketones*<br><br>***B*** *is incorrect because* ***Y*** *is not the only molecule which is a methyl ketone*<br><br>***D*** *is incorrect because* ***Z*** *is not the only molecule which is a methyl ketone* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| **13(b)** | **The only correct answer is C** (**W** and **X** only)<br><br>***A*** *is incorrect because* ***X*** *also gives a positive result*<br><br>***B*** *is incorrect because* ***W*** *also gives a positive result*<br><br>***D*** *is incorrect because neither* ***Y*** *nor* ***Z*** *gives a positive result* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| **13(c)** | **The only correct answer is D** (**W**, **X** and **Y** only)<br><br>***A*** *is incorrect because* ***Y*** *has a* $CH_3CH_2$ *group likely to produce a mass spectrum fragment with a m / e = 29*<br><br>***B*** *is incorrect because* ***W*** *has a HCO group likely to produce a mass spectrum fragment with a m / e = 29*<br><br>***C*** *is incorrect because* ***Z*** *would not be expected to produce a mass spectrum fragment with a m / e = 29* | **(1)** |

**TOTAL FOR SECTION A = 20 MARKS**

**Section B**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **14(a)(i)** | • $K_p = \frac{p(C_2H_5OH)}{p(C_2H_4) \times p(H_2O)}$ | Allow without brackets<br>Allow pp for p<br>Allow p inside brackets<br>Do not award square brackets<br>Do not award omission of 'p'<br>Penalise omission of $K_p$ | **(1)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **14(a)(ii)** | An answer that makes reference to the following points:<br>• calculation of moles at equilibrium **(1)**<br>• calculation of mole fractions at equilibrium **(1)**<br>• calculation of partial pressures at equilibrium **(1)**<br>• substitution of values into equation and calculation of $K_p$ **(1)**<br>• units **(1)** | <u>Example of calculation</u><br>Ethene / Steam / Ethanol<br>Initial moles: 1.00 / 1.00 / 0.00<br>Equilibrium moles: 0.570 / 0.570 / 0.430<br>Mole fraction (MF): 0.363 / 0.363 / 0.274<br>Partial pressure (MF x 50.0): 18.15(3) / 18.15(3) / 13.69(4)<br>$K_p = (13.694 \div 18.153^2) =$ 0.0416 / 0.041557<br>$atm^{-1}$<br>TE on expression in (a)(i) and at each stage<br>Ignore SF except 1SF<br>Correct answer with some working scores (5) | **(5)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **14(b)** | An answer that makes reference to the following points:<br><br>• high pressure favours the formation of ethanol<br><br>**and**<br>because 2 mol (of gas from 1 mol) **(1)**<br><br>• high temperature does not favour the formation of ethanol<br><br>**and**<br>because the (forward) reaction is exothermic **(1)**<br><br>• high temperature is needed because otherwise the rate of reaction is too slow **(1)** | Allow reverse arguments<br>Ignore comments about $K_c$ / $K_p$<br><br>Allow high pressure increases yield (of ethanol)<br>Allow reactions shifts to the right at high temperature<br><br>Allow fewer moles on the right hand side<br><br>Allow high temperature decreases yield (of ethanol)<br>Allow reaction shifts to the left at high temperature<br><br>Accept because the reverse reaction is endothermic<br><br>Allow unconverted reactants can be recycled to increase the overall yield<br>Ignore higher temperature increases rate<br><br>If no other mark is scored, Allow (1) for:<br>High pressure increases yield / causes equilibrium to shift to right<br>**and**<br>High temperature reduces yield / causes equilibrium to shift to left | **(3)** |

**(Total for Question 14 = 9 marks)**

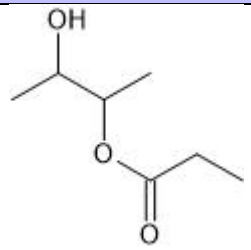
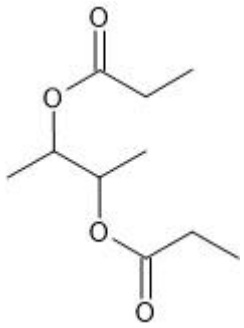
| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **15(a)** | An answer that makes reference to the following points:<br>• balancing of reducing agent **(1)**<br>• butane-2,3-diol structure **(1)** | Example of equation<br>$CH_3COCOCH_3 + 4[H] \rightarrow CH_3CHOHCHOHCH_3$<br>Do not award if any other additional product given<br>Allow any unambiguous structure- skeletal/displayed/hybrid<br>Do not award $CH_3COH_2COH_2CH_3$ | **(2)** |

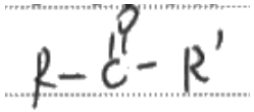
| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **15(b)** | An answer that makes reference to the following point:<br>• go colourless / yellow-green colour disappears | | **(1)** |

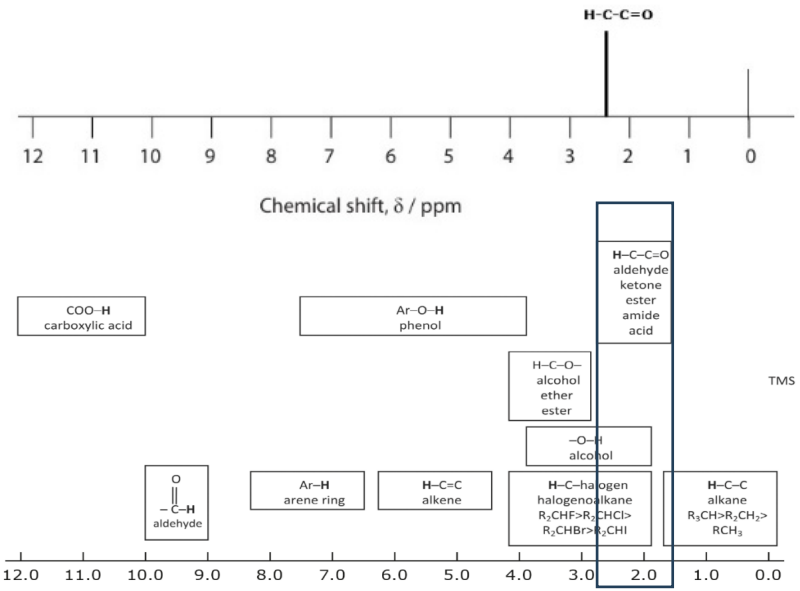
| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **15(c)** | An answer that makes reference to the following points:<br>• butane-2,3-diol (has the highest boiling temperature) **and** because (only) it has hydrogen bonding **(1)**<br>• which requires more **energy** to break **(1)** | Reference to butane-2,3-dione having the higher boiling temperature scores (0)<br>Ignore hydrogen bonding is the strongest intermolecular force<br>Ignore hydrogen bonds are stronger than other intermolecular forces<br>Do not award any implication that covalent bonds within butane-2,3-diol are broken | **(2)** |

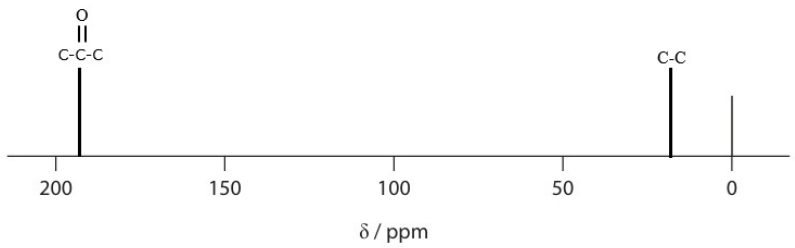
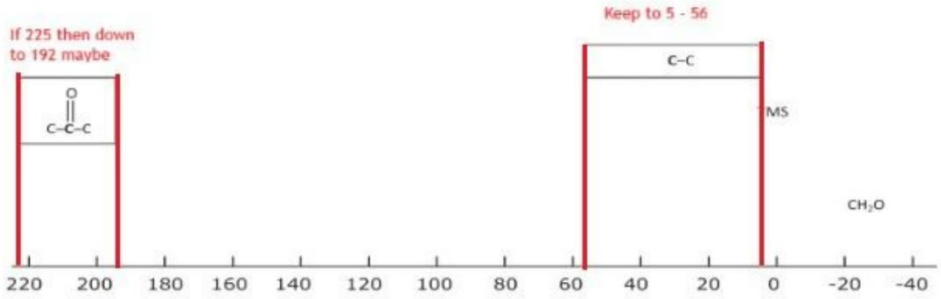
| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **15(d)** | An answer that makes reference to the following points:<br><br>• optical isomerism **(1)**<br><br>• because of the presence of (two) chiral carbon(s)<br><br>**or**<br>because it forms non-superimposable mirror images **(1)** | <br><br>Allow optical isomer<br>Allow it is optically active<br>Ignore the number of isomers if given<br><br>Allow butane-2,3-diol is (a) chiral (molecule)<br>Allow because of the presence of a carbon with four different groups/atoms attached / asymmetric carbon atom(s)<br>Ignore just reference to enantiomers<br>Ignore references to rotation of (plane) polarised light | **(2)**<br><br>\ |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **15(e)(i)** | An answer that makes reference to the following points:<br><br>• the reaction is irreversible (not reversible) **(1)**<br><br>• by-product is hydrogen chloride not water **(1)**<br><br>• the reaction is fast / occurs at room temperature so no acid catalyst needed **(1)** | Accept reverse arguments<br><br>Allow reaction (with propanoyl chloride) goes to completion<br>Allow (propanoyl chloride) gives a higher yield<br><br>Allow misty / steamy fumes for HCl<br><br>Allow vigorous for fast<br>Ignore comments about differences in reaction mechanisms/atom economy | **(3)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 15(e)(ii) | • skeletal formula with one ester group **(1)**<br><br>• skeletal formula with two ester groups **(1)** | <br><br><br><br>Diester skeletal formula scores (2)<br><br>Displayed /structural/hybrid formulae for the diester scores (1)<br><br>Penalise extra -$CH_2$- groups once only<br><br>Penalise polymer brackets once only | **(2)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **15(f)** | An answer that makes reference to the following points:<br><br>• butanedione has a C=O absorption at 1720–1700 ($cm^{-1}$ but butane-2,3-diol does not) **(1)**<br><br>• butane-2,3-diol has a O−H absorption at 3750–3200 ($cm^{-1}$ but butane-2,3-diol does not) **(1)** | For both, allow single numbers within the quoted ranges<br><br>Do not award –C=O or <br><br>Allow OH bond but not just OH<br>Do not award -O-H<br><br>Two correct wavenumber ranges without bonds scores (1)<br>Ignore C-H absorptions<br>Ignore C-O in the diol but NOT in the dione<br>Penalise additional incorrect absorptions once only. | **(2)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 15(g) | • $^{1}$H spectrum with one singlet peak or line **(1)** | Accept labels for peaks drawn on butane-2,3-dione<br>Penalise missing labels once only<br>Ignore shape of peak / line<br>Ignore height of lines<br>Ignore peak area, even if incorrect<br><br><u>Example of H-1 spectra</u><br><br><br><br>Accept a single peak / line in the range 1.6 – 2.8<br>Do not award any splitting of line | **(3)** |

| | | | |
|---|---|---|---|
| | • $^{13}C$ spectrum peak / line for carbonyl carbon **(1)**<br><br>• $^{13}C$ spectrum peak / line for alkyl carbon **(1)** | Example of C-13 spectra<br><br>**$^{13}C$ nuclear magnetic resonance chemical shifts relative to tetramethylsilane (TMS)**<br><br>Accept a peak / line in the range of 195 - 225 for carbonyl carbon<br><br>Accept a peak / line in the range of 5 – 56 for alkyl carbon<br><br>Penalise splitting of C-13 peaks once only if not penalised in H-1 spectrum | |

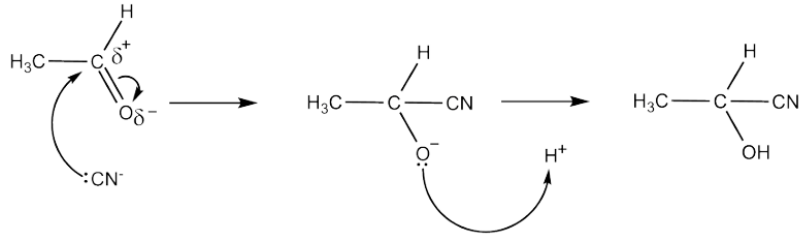
**(Total for Question 15 = 17 marks)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*16</td>
<td>
This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.<br><br>
Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.<br><br>
The following table shows how the marks should be awarded for indicative content.
<table>
<tr><td>Number of indicative marking points seen in answer</td><td>Number of marks awarded for indicative marking points</td></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
The following table shows how the marks should be awarded for structure and lines of reasoning
<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained lines of reasoning</td></tr>
<tr><td>Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>
</td>
<td>
Guidance on how the mark scheme should be applied.<br><br>
The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).<br><br>
If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).<br><br>
In general it would be expected that<br>
5 or 6 indicative points would get 2 reasoning marks<br>
3 or 4 indicative points would get 1 reasoning mark<br>
0, 1 or 2 indicative points would get zero reasoning marks<br><br>
If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).<br><br>
Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning<br><br>
Allow reverse arguments throughout
</td>
<td>(6)</td>
</tr>
</table>

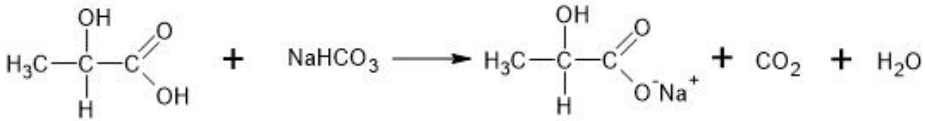
| | | | |
|---|---|---|---|
| | **Indicative content**<br><br>**IP1** the bonding in potassium chloride is (almost) 100% ionic<br>**and**<br>as the theoretical and Born-Haber values are (very) similar<br><br>**IP2** the bonding in calcium iodide has some covalent character<br>**and**<br>as the theoretical and Born-Haber values are different<br><br>**IP3** the anion/iodide ion in calcium iodide is more polarised (than in potassium chloride<br><br>**IP4** the calcium ion has greater charge density so greater polarising power<br><br>**IP5** the iodide ion is larger (than the chloride ion and so is more easily polarised)<br><br>**IP6** the bonding in calcium iodide is stronger than the bonding in potassium chloride because the charge on the calcium ion is twice as large (as the charge on the potassium ion) | Penalise **molecules** once in whole answer.<br><br>Allow calculated difference in values for IP1 & IP2<br><br>Allow IP1 and IP2 if bonding in KCl is 100% ionic **and** $CaI_2$ has covalent character, **and** difference is larger in $CaI_2$ (than in KCl)<br>If IP1 and IP2 not scored then allow 1IP for bonding in KCl is 100% ionic and $CaI_2$ has covalent character<br><br>Allow even if comparing $CaCl_2$ with KCl providing it is clear that it is the anion being polarised.<br>Can be inferred from an IP5 statement so long as linked to larger size of $Ca^{2+}$<br>Ignore $CaI_2$ is more polarised (than KCl)<br><br>Allow the calcium ion has greater charge / is smaller than a potassium ion so has greater polarising power<br>Ignore references to size of an anion<br><br>Polarisation must be mentioned at least once in IP3 or IP4.<br>Penalise lack of comparative language one only in IP4,IP5 & IP6<br><br>Allow if $Ca^{2+}$ and $K^{+}$ are seen anywhere in answer<br>Allow calcium iodide has stronger bonding (than expected) due to having covalent character.<br><br>Penalise reference to atoms instead of ions once only in IP3 to IP5. | |

**(Total for Question 6 = 6 marks)**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **17(a)** | An answer that makes reference to the following point<br><br>• 2-hydroxypropanoic acid | <br><br>Ignore punctuation<br>Allow 2-hydroxylpropanoic acid | **(1)** |

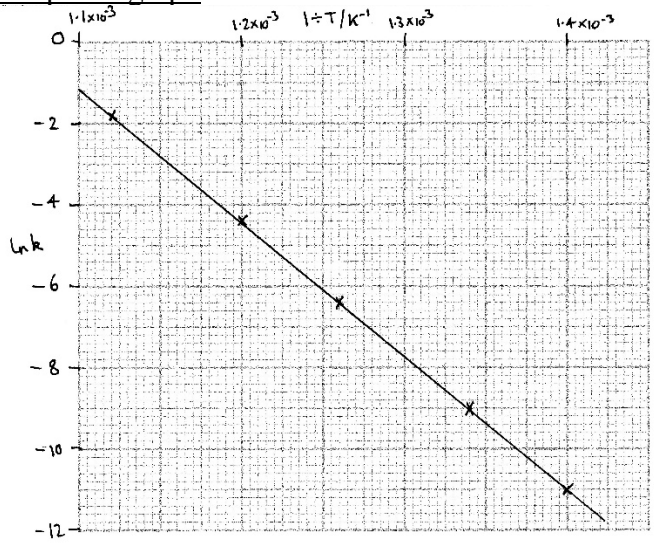
| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **17(b)(i)** | • dipole on C=O bond<br>• curly arrow from C=O bond to O or just beyond<br>• lone pair on the C of cyanide ion<br>• curly arrow from C of cyanide ion to C of C=O<br>• structure of intermediate, including charge<br>• lone pair on O of intermediate<br>• $H^+$ or $H^{\delta+}$ of HCN/$H_2O$<br>• curly arrow from O to $H^+$/HCN/$H_2O$<br><br>8 points scores (4)<br>6 – 7 scores (3)<br>4 – 5 scores (2)<br>2 – 3 scores (1) | <u>Example of mechanism</u><br><br><br><br>Lone pair must be wholly placed on the C<br>If lone pair placed on N of $CN^-$ , allow curly arrow from this lone pair<br><br>If curly arrow goes to H of HCN / $H_2O$ there must be a 2nd arrow from H-C bond to C / H-O bond to O<br><br>If lone pair present for BP 3 and/or BP 6, curly arrow must come from lone pair.<br>If lone pair not present for BP 3 and/or BP6, curly arrow may come from anywhere on C or O. | **(4)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **17(b)(ii)** | An answer that makes reference to the following point:<br><br>• hydrolysis | Allow acid / acidic hydrolysis<br>Allow base / basic hydrolysis<br>Allow alkali / alkaline hydrolysis<br>Do not award hydration / dehydration / substitution | **(1)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **17(c)** | • correct equation | Accept displayed/structural/skeletal formulae or combination thereof<br>Example of equation<br><br>Ignore state symbols even if incorrect<br>Allow $H_2CO_3$<br>Allow without charges on $O^-$ $Na^+$<br>Do not award covalent bond drawn between O and Na | **(1)** |

**(Total for Question 17 = 7 marks)**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **18(a)(i)** | • $(1 \div T =)$ 1.26 x $10^{-3}$ **1)**<br>**and**<br>$(\ln k =) -4.40$ **1)** | Both values must be to 2DP | **(1)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **18(a)(ii)** | • axes correct way round and labelled **(1)**<br><br>• suitable scale with points covering at least half the axes in both directions **(1)**<br><br>• all points plotted ±1 small square and straight line **(1)** | Do not award t for *T*<br>Do not award lnK scale inverted (ie 0 at bottom, -12 at top)<br><br>Allow x $10^{-3}$ to be to be part of the units on the x-axis<br><br><u>Example of graph</u><br><br> | **(3)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **18(a)(iii)** | • calculation of gradient of line with sign **(1)**<br>• K unit for gradient **(1)**<br>• calculation of activation energy **(1)** | Gradient range −32000 to −33700<br>Can be calculated using the points in the table<br>No TE for incorrect units on graph<br>Example of calculation<br>$E_a$ =(−32857 x −8.31 ÷ 1000=) 273 (kJ $mol^{-1}$)<br>$E_a$ range 265.9 to 280.0<br>Allow final answer in J $mol^{-1}$ but units must be stated<br>TE from incorrect gradient but $E_a$ must be positive<br>Ignore SF except for 1SF<br>Do not award negative $E_a$ | **(3)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **18(b)** | An answer that makes reference to the following points:<br><br>• rate constant *k* increases with increasing temperature **(1)**<br><br>• so a greater proportion of collisions / molecules / particles have energy greater or equal to the activation energy **(1)**<br><br>• so the frequency of successful collisions increases **(1)**<br>**or**<br>more successful collisions per unit time | Allow ln*k* increases<br>Ignore reference to 1/T<br>Ignore any reference to equilibrium constant<br><br>Allow more particles have enough energy to react<br>Allow more for greater proportion of<br><br>Allow effective for successful | **(3)** |

**(Total for Question 18 = 10 marks)**
**TOTAL FOR SECTION B = 49 MARKS**

**Section C**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **19(a)(i)** | An answer that makes reference to two of the following points:<br><br>• bubbles / fizzing / effervescence **(1)**<br><br>• liquid / paste produced **(1)**<br><br>• temperature decreases **(1)**<br><br>• pungent smell (of ammonia) **(1)** | Apply list principle<br><br>Ignore gas formed<br><br>Allow solid(s) turn to liquid(s)<br>Ignore solid disappears / decreases<br>Do not award (white) precipitate<br><br>Do not award smell of rotten eggs<br><br>Ignore chemical tests for water and ammonia | **(2)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **19(a)(ii)** | An answer that makes reference to the following points:<br><br>• (high) positive value expected<br><br>**and**<br>because a gas is formed (from (two) solid(s)) **(1)**<br><br>• because increase in moles / 3 mol to 13 mol **(1)** | <br><br>Allow $\Delta S_{sys} > 0$<br>Ignore $\Delta S_{sys}$ increases<br><br>Allow because liquid formed from (two) solid(s)<br><br>If number of moles quoted they must be correct<br>Allow more moles of gas on RHS<br>Allow molecules / particles / species for moles | **(2)** |

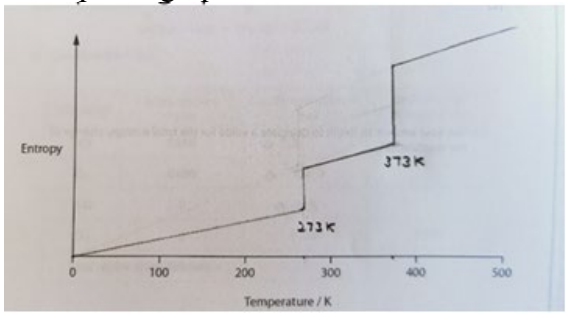
| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **19(b)(i)** | • calculation of sum of entropy of products **(1)**<br><br>• calculation of sum of entropy of reactants **(1)**<br><br>• calculation of entropy of the system **(1)** | <u>Example of calculation</u><br>$\sum S^{o}_{(products)}$ = ((2 x 192.3) + (2 x 69.9) + 213.8 =)<br>(+)738.2 (J $K^{-1}$ $mol^{-1}$)<br><br>$\sum S^{o}_{(reactants)}$ = ((2 x 151.1) + 99.7 =)<br>= (+)401.9 (J $K^{-1}$ $mol^{-1}$)<br><br>$\Delta S^{o}_{system}$ = (738.2 – 401.9 =)<br>= (+)336.3 (J $K^{-1}$ $mol^{-1}$)<br><br>Ignore SF except 1SF<br>Ignore units, even if incorrect<br>Correct answer with no working scores (3)<br>TE throughout | **(3)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 19(b)(ii) | • calculation of sum of enthalpy change of formation of products **(1)**<br><br>• calculation of sum of enthalpy change of formation of reactants **(1)**<br><br>• calculation of enthalpy change of reaction **(1)** | Example of calculation<br>$\sum \Delta H^{o}_{(products)}$ = ((2 x −285.8) + (2 x −46.1) + −992.1=)<br>= −1655.9 (kJ mol$^{-1}$)<br><br>$\sum \Delta H^{o}_{(reactants)}$ = ((2 x −365.6) + −944.7 =)<br>= −1675.9 (kJ mol$^{-1}$)<br><br>$\Delta r H^{o}$ = (−1655.9 – −1675.9 =)<br>= (+) 20.0 (kJ mol$^{-1}$)<br><br>Ignore SF except 1SF<br>Ignore units, even if incorrect,<br>Correct answer with no working scores (3)<br>TE throughout<br>–20 (kJ mol$^{-1}$) scores (2) | **(3)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **19(b)(iii)** | • calculation of entropy of the surroundings **(1)**<br><br>• calculation of total entropy change with **sign and units** **(1)** | Example of calculation<br>$\Delta S^{\ominus}_{surroundings} = ( - \Delta H \div T)$ $= (- 20\,000 \div 298)$<br>$= - 67.1141 / - 67.1$ (J $K^{-1}$ $mol^{-1}$)<br><br>$\Delta S^{\ominus}_{total} = \Delta S^{\ominus}_{system} + \Delta S^{\ominus}_{surroundings}$<br>$\Delta S^{\ominus}_{total} = (+336.3 - 67.1)$<br>$= +269.2$ J $K^{-1}$ $mol^{-1}$<br>Allow +0.269 kJ $K^{-1}$ $mol^{-1}$<br><br>Ignore SF except 1SF<br>Correct answer with no working scores (2)<br>TE throughout except for negative values of $\Delta S^{\ominus}_{total}$ | **(2)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **19(c)(i)** | An answer that makes reference to the following points:<br><br>• (molecules of) chlorine disperse/diffuse into the top jar **(1)**<br><br>• they have greater entropy (because they are more spread out/ random) **(1)** | Allow chlorine mixes with the air (in the top jar)<br>Allow chlorine moves into the top jar<br><br>Allow disorder / randomness for entropy<br>Ignore the molecules / chlorine is more dispersed for M2 | **(2)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 19(c)(ii) | An answer that makes reference to the following points:<br>• correct completion of bottom three rows | <table><tr><th>Molecule A</th><th>Molecule B</th></tr><tr><td>2</td><td>2</td></tr><tr><td>3</td><td>1</td></tr><tr><td>1</td><td>3</td></tr><tr><td>4</td><td>0</td></tr><tr><td>0</td><td>4</td></tr></table><br>Accept rows in any order | (1) |

| Question Number | Answer | | Additional Guidance | Mark |
|---|---|---|---|---|
| 19(d) | • general shape of increase from left to right | (1) | Allow horizontal sections between phase changes<br>Allow a straight / curved line | (3) |
| | • two vertical stages for melting and boiling | (1) | Ignore height of lines | |
| | • include the use of 273 for melting and 373 for boiling either by labelling or position on x axis | (1) | <u>Example of graph</u><br> | |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **19(e)** | An answer that makes reference to two of the following points:<br><br>• in the solid/lattice the ions are **fixed** **(1)**<br><br>• but in solution the ions are mobile (so more dispersed) **(1)**<br><br>• and the hydrogen bonds between molecules of water are disrupted **(1)** | Allow there are more ways of arranging the ions / energy quanta<br>Allow particles for ions in M2 only<br><br>If no other mark awarded, allow (1) for an increase in the number of species / particles<br>Do not award reference to molecules other than water<br>Do not award increase in the number of ions<br>Penalise reference to atoms once only | **(3)** |

**(Total for Question 19 = 21 marks)**
**TOTAL FOR SECTION C = 21 MARKS**
**TOTAL FOR PAPER = 90 MARKS**