



# Mark Scheme (Results)

January 2020

Pearson International Advanced Level  
In Chemistry (WCH14)  
Paper 01 Rates, Equilibria and Further  
Organic Chemistry

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### **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.

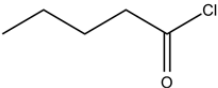
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

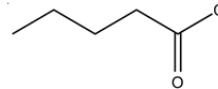
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.

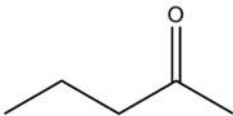
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

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.

Section A (multiple choice)

Question Number	Answer	Mark
1(a)	<p>The only correct answer is <b>A</b> (compound 1)</p>  <p><i>B is incorrect as aldehydes do not change the pH of water C is incorrect as ketones do not change the pH of water D is incorrect as amides do not change the pH of water</i></p>	1

Question Number	Answer	Mark
1(b)	<p>The only correct answer is <b>A</b> (compound 1)</p>  <p><i>B is incorrect as aldehydes do not react with amines to form an N-substituted amide C is incorrect as ketones do not react with amines D is incorrect as amides do not react with amines</i></p>	1

Question Number	Answer	Mark
1 (c)	<p>The only correct answer is <b>C</b> (compound 3)</p>  <p><i>A is incorrect as it does not form iodoform B is incorrect as it does not form iodoform D is incorrect as it does not form iodoform</i></p>	1
2	<p>The only correct answer is <b>C</b> (<math>\text{ClCH}_2\text{C}(\text{CH}_3)(\text{Cl})\text{COOH}</math>)</p> <p><i>A is incorrect as compound 1 does not have a chiral carbon atom B is incorrect as compound 2 does not have a chiral carbon atom D is incorrect as compound 4 does not have a chiral carbon atom</i></p>	1
3	<p>The only correct answer is <b>B</b> (condensation)</p> <p><i>A is incorrect as neither monomer has a carbon-carbon double bond C is incorrect as this is not a type of polymerisation D is incorrect as this is not a type of polymerisation</i></p>	1

Question Number	Answer	Mark
4	<p>The only correct answer is <b>A</b> (<math>\text{NaOOCCH}=\text{CHCOONa}</math>)</p> <p><i>B is incorrect as only one of the -COOH groups has reacted</i></p> <p><i>C is incorrect as OH groups have added across the double bond</i></p> <p><i>D is incorrect as only one of the -COOH groups has reacted, and a -COOH group has been reduced</i></p>	1

Question Number	Answer	Mark
5	<p>The only correct answer is <b>C</b></p> <p>Diagram 3</p> <p><i>A is incorrect as it shows a primary halogenoalkane forming a carbocation</i></p> <p><i>B is incorrect as it shows a primary halogenoalkane forming a carbocation and the electrons are moving to a lone pair in the second step</i></p> <p><i>D is incorrect as the electrons are moving to a lone pair in the first step</i></p>	1

Question Number	Answer	Mark
6	<p>The only correct answer is <b>D</b> (phosphorus(V) chloride)</p> <p><i>A is incorrect as chlorine will not react with ethanoic acid to form ethanoyl chloride</i></p> <p><i>B is incorrect as chloroethane will not react with ethanoic acid to form ethanoyl chloride</i></p> <p><i>C is incorrect as hydrogen chloride will not react with ethanoic acid to form ethanoyl chloride</i></p>	1

Question Number	Answer	Mark
7	<p>The only correct answer is <b>B</b> (<math>\text{Hg}(l) \rightarrow \text{Hg}(g)</math>)</p> <p><i>A is incorrect as the increase in disorder from (s) to (l) is less than that from (l) to (g) C is incorrect as there is a decrease in disorder as the gaseous ion is hydrated</i></p> <p><i>D is incorrect as there is no significant change in number of particles or state.</i></p>	1

Question Number	Answer	Mark
8	<p>The only correct answer is <b>D</b> (W, X, Y and Z but there is more Y and Z than W and X)</p> <p><i>A is incorrect as this requires in a very large value for <math>K_c</math></i></p> <p><i>B is incorrect as this will result in a very small value for <math>K_c</math>, <math>&lt; 1</math></i></p> <p><i>C is incorrect as this will result in a small value for <math>K_c</math>, <math>&lt; 1</math></i></p>	1

Question Number	Answer	Mark
9	<p>The only correct answer is <b>A</b> (sum of enthalpies of hydration of the gaseous ions)</p> <p><i>B is incorrect as it would be <math>\text{Li}(s) + \frac{1}{2}\text{Cl}_2(g) \rightarrow \text{LiCl}(s)</math></i></p> <p><i>C is incorrect as it would be <math>\text{LiCl}(s) \rightarrow \text{Li}^+(aq) + \text{Cl}^-(aq)</math> D is incorrect as it would be <math>\text{Li}^+(g) + \text{Cl}^-(g) \rightarrow \text{LiCl}(s)</math></i></p>	1



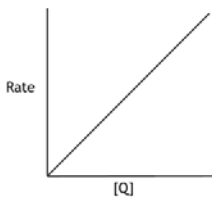
Question Number	Answer	Mark
10	<p>The only correct answer is <b>D</b> (require 20 cm<sup>3</sup> of 0.10 mol dm<sup>-3</sup> NaOH (aq) to react completely)</p> <p><i>A is incorrect as one acid is strong, the other is weak</i> <i>B is incorrect as the solutions have different concentrations and ethanoic acid is a weak acid</i> <i>C is incorrect as the solutions have different concentrations and ethanoic acid is a weak acid</i></p>	1

Question Number	Answer	Mark
11	<p>The only correct answer is <b>B</b> (HCOOH(aq) and KOH(aq))</p> <p><i>A is incorrect as both the acid and base are strong</i> <i>C is incorrect as the acid is strong and the base is weak</i> <i>D is incorrect as both the acid and base are weak</i></p>	1

Question Number	Answer	Mark
12	<p>The only correct answer is <b>C</b> (between 11 and 13)</p> <p><i>A is incorrect the solution is a strong base whose concentration is <math>&gt; 1 \times 10^{-5} \text{ mol dm}^{-3}</math></i> <i>B is incorrect the solution is a strong base whose concentration is <math>&gt; 1 \times 10^{-3} \text{ mol dm}^{-3}</math></i> <i>D is incorrect the solution is a strong base whose concentration is <math>&lt; 1 \times 10^{-1} \text{ mol dm}^{-3}</math></i></p>	1

Question Number	Answer	Mark
13(a)	<p>The only correct answer is <b>C</b> (flasks 1 and 4 only)</p> <p><i>A is incorrect as flask 4 also contains only substances from the right-hand side of the equilibrium (HCl(aq) includes some water)</i></p> <p><i>B is incorrect as flask 1 also contains only substances from the right-hand side of the equilibrium D is incorrect as flasks 2 and 3 do not contain any ester</i></p>	1

Question Number	Answer	Mark
13(b)	<p>The only correct answer is <b>A</b> (the equilibrium reaction is slow)</p> <p><i>B is incorrect as rapid hydrolysis would affect the position of the equilibrium C is incorrect as the acid is neutralised</i></p> <p><i>D is incorrect as although a buffer may form it does not affect the position of the ester equilibrium</i></p>	1

Question Number	Answer	Mark
14	<p>The only correct answer is <b>C</b></p>  <p><i>A is incorrect as it shows a 0 order reaction B is incorrect as it shows a 0 order reaction</i></p> <p><i>D is incorrect as the concentration of Q remains constant</i></p>	1

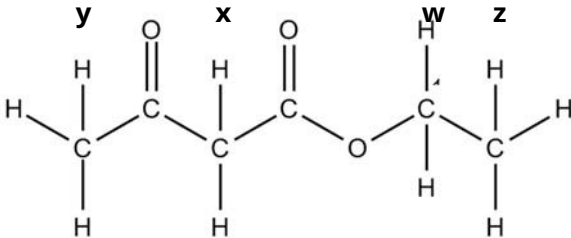
Question Number	Answer	Mark
15(a)	<p>The only correct answer is <b>D</b> (when the concentration of nitrogen monoxide doubles and the concentration of oxygen quadruples, the rate increases by a factor of 8)</p> <p><i>A is not an incorrect statement as the overall order is 3</i> <i>B is not an incorrect statement as the rate can be measured in units of mol dm<sup>-3</sup> s<sup>-1</sup></i> <i>C is not an incorrect statement as increasing the pressure does increase the rate of the reaction</i></p>	1

Question Number	Answer	Mark
15(b)	<p>The only correct answer is <b>D</b> (dm<sup>6</sup> mol<sup>-2</sup> s<sup>-1</sup>)</p> <p><i>A is incorrect as these are the units for a fourth overall order rate equation B is incorrect as the exponent values are incorrect</i> <i>C is incorrect as the signs on the exponent values for mol and dm are incorrect.</i></p>	1

Question Number	Answer	Mark
15(c)	<p>The only correct answer is <b>A</b> (1.31 x 10<sup>-2</sup>)</p> <p><i>B is incorrect as it is the value for [NO]<sup>2</sup></i> <i>C is incorrect as the values for [O<sub>2</sub>] and rate are the wrong way round in the calculation, and the square root of the calculated value has not been determined</i> <i>D is incorrect as the values for [O<sub>2</sub>] and rate are the wrong way round in the calculation</i></p>	1

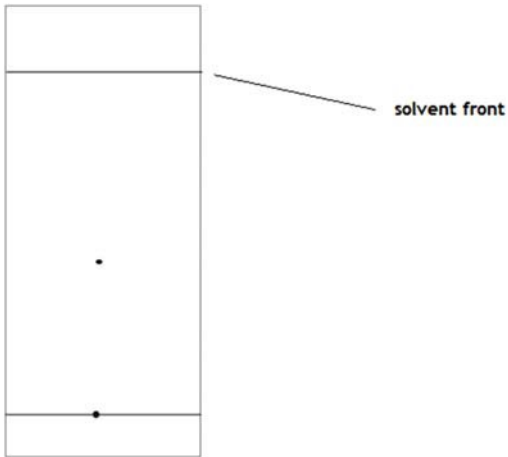
(Total for Section A = 20 marks)

Section B

Question Number	Answer	Additional Guidance	Mark
16(a)(i)	 <p>(2)</p> <p>All 4 peaks correctly matched scores both marks 2 or 3 peaks correctly matched scores 1 mark 0 or 1 peak correctly matched scores 0 marks</p>	NOTE Allow labels to/near to carbon of correct group	2

Question Number	Answer	Additional Guidance	Mark
16(a)(ii)	<p>4.2 ppm quartet due to 3 hydrogen (atoms) on adjacent carbon (1)</p> <p>1.3 ppm triplet due to 2 hydrogen (atoms) on adjacent carbon (1)</p>	<p>Allow 'due to adjacent CH<sub>3</sub>'</p> <p>Allow 'due to adjacent CH<sub>2</sub>'</p> <p>If neither mark awarded can score 1 for correct reference to n+1 rule</p> <p>If no reference to splitting patterns then allow 1 for correctly identifying both sets of adjacent hydrogens</p>	2

Question Number	Answer	Additional Guidance	Mark
16(a)(iii)	$C(CH_3)_3COCOOH$	Allow skeletal or displayed formulae If more than 1 structure type given, both must be correct.	1

Question Number	Answer	Additional Guidance	Mark
16(b)(i)	<p>Origin/start line shown above bottom of paper (1)</p> <p>Straight line for solvent front added and labelled (1)</p> <p><b>Spot</b> due to ethyl-3-oxobutanoate in position consistent with <math>R_f</math> between 0.4 and 0.5 (1)</p>	<p>Ignore omission of initial spot, but if shown must be on baseline</p> <p>Allow 'distance travelled by solvent' Do not award wavy lines</p> <p>Do not award the top of the paper as the solvent front</p>  <p>The diagram shows a vertical rectangular TLC plate. At the bottom, there is a horizontal line representing the baseline. A single small black dot (spot) is located above the baseline. Near the top of the plate, there is another horizontal line representing the solvent front. A label 'solvent front' with a pointer line indicates this top line.</p>	3

Question Number	Answer	Additional Guidance	Mark
16(b)(ii)	<p><b>M1</b> As only London forces form between them (so spot moves a shorter distance) / ethyl-3-oxobutanoate is polar, hexane is non-polar / (1)</p> <p><b>M2</b> Weaker interaction between hexane and ethyl-3-oxobutanoate / ethyl-3-oxobutanoate is less soluble in hexane (1)</p>	<p>Allow reverse arguments Do not award M1 if reference to hydrogen bonds</p> <p>Allow solvent / mobile phase for hexane</p> <p>Allow ethyl-3-oxobutanoate does not dissolve in hexane</p>	2

(Total for Question 16 = 10 marks)

Question Number	Answer	Additional Guidance	Mark																				
17	<p>This question assesses the student’s ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.</p> <p>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.</p> <p>The following table shows how the marks should be awarded for indicative content.</p> <table border="1" data-bbox="449 634 1234 883"> <thead> <tr> <th>Number of indicative marking points seen in answer</th> <th>Number of marks awarded for indicative marking points</th> </tr> </thead> <tbody> <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> </tbody> </table> <p>The following table shows how the marks should be awarded for structure and lines of reasoning</p> <table border="1" data-bbox="449 951 1283 1328"> <thead> <tr> <th></th> <th>Number of marks awarded for structure of answer and sustained lines of reasoning</th> </tr> </thead> <tbody> <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> </tbody> </table>	Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points	6	4	5-4	3	3-2	2	1	1	0	0		Number of marks awarded for structure of answer and sustained lines of reasoning	Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2	Answer is partially structured with some linkages and lines of reasoning	1	Answer has no linkages between points and is unstructured	0	<p>Guidance on how the mark scheme should be applied: The mark for indicative content should be added to the mark for lines of reasoning. Foreexample, a response with four 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).</p> <p>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 zero marks for linkages).</p> <p>In general it would be expected that 5 or 6 indicative points would score 2 reasoning marks, and 3 or 4 indicative points would score 1 reasoning mark. A total of 2, 1 or 0 indicative points would score 0 marks for reasoning.</p>	6
Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points																						
6	4																						
5-4	3																						
3-2	2																						
1	1																						
0	0																						
	Number of marks awarded for structure of answer and sustained lines of reasoning																						
Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2																						
Answer is partially structured with some linkages and lines of reasoning	1																						
Answer has no linkages between points and is unstructured	0																						

	<p>Indicative Points Similarities:</p> <p><b>IP1 Both</b> react with 2,4-dinitrophenylhydrazine to form a yellow / orange / red precipitate</p> <p><b>IP2 Both</b> can be reduced by LiAlH<sub>4</sub> / Lithium tetrahydrido aluminate / lithium aluminium hydride (in dry ether)</p> <p>Differences:</p> <p><b>IP3</b> but propanal forms a primary alcohol, propanone forms a secondary alcohol</p> <p><b>IP4</b> Propanal will react with acidified potassium dichromate ((VI)) but propanone will not react</p> <p><b>IP5</b> Equation for oxidation reaction</p> <p><b>IP6</b> Observation for named oxidising agent Eg. orange to green (with acidified dichromate(VI))</p> <p>Comment - Ignore equations involving 2,4 DNP</p>	<p>Ignore Iodoform reaction</p> <p>Accept <b>Both</b> can be reduced by NaBH<sub>4</sub> If name given it must be correct</p> <p>Accept propanal forms propan- 1-ol / CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>OH and propanone forms propan-2-ol / CH<sub>3</sub>CHOHCH<sub>3</sub></p> <p>Accept any named suitable oxidising agent eg. Fehling's / Benedict's solution/ Tollens' reagent / acidified potassium manganate((VII))</p> <p>CH<sub>3</sub>CH<sub>2</sub>CHO + [O] → CH<sub>3</sub>CH<sub>2</sub>COOH If reduction of metal shown in oxidation equation it must be correct.</p> <p>Fehling's / Benedict's : blue solution to red / orange ppt Tollen's : silver mirror / ppt Allow grey ppt.</p> <p>Additional incorrect equations for organic reduction loses one reasoning mark</p>	
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(Total for Question 17 = 6 marks)



Question Number	Acceptable Answers	Additional Guidance	Mark
18(a) (i)	<ul style="list-style-type: none"> <li>Calculation of <math>1/T</math> value <math>1.19 \times 10^{-3}</math></li> </ul> <p><b>and</b></p> <ul style="list-style-type: none"> <li>Calculation <math>\ln k</math> value -6.40</li> </ul> <p>(1)</p>	Both values must be given to 3sf.	1

Question Number	Acceptable Answers	Additional Guidance	Mark
18(a)(ii)	<p><b>M1</b> Axes correct way round and labelled (1)</p> <p><b>M2</b> Suitable scale with points covering at least half the axes in both directions (1)</p> <p><b>M3</b> All points plotted (<math>\pm \frac{1}{2}</math> square), <b>and</b> <u>straight</u> line of best fit (1)</p>	<p>If numbers used on x-axis are without the power of ten allow <math>\times 10^3</math> or <math>10^{-3}</math> on the axis.</p> <p>Do not award M1 if units given for <math>\ln k</math> on y-axis</p> <p>Do not award small "t" for "T"</p> <p>Ignore y-axis with increasing negative values going upwards.</p> <p>COMMENT: If wrong columns plotted allow M2 only</p>	3

Question Number	Acceptable Answers	Additional Guidance	Mark
<b>18(a)(iii)</b>	M1 Calculation of gradient with sign, in the range -34200 to -31200 (1) M2 Units of gradient is K (1) M3 Calculation of activation energy (1)	Do not award positive gradient. Allow gradient as a fraction  <u>Example of calculation:</u> (32700 x 8.31) / 1000 = (+)272 (kJ mol <sup>-1</sup> ) Allow any answer between (+)259 and 284 Allow answer in J mol <sup>-1</sup> if units given Allow TE from M1 if E <sub>a</sub> is positive. Ignore SF other than 1SF Do not award negative E <sub>a</sub>	<b>3</b>

Question Number	Acceptable Answers	Additional Guidance	Mark
18(b)	<p>The value is large,</p> <p><b>Either</b></p> <p>as a lot of energy is required (1)</p> <p>so the reactant is kinetically stable / rate of reaction is low (1)</p> <p><b>Or</b></p> <p>as a lot of energy is required (1)</p> <p>to break the strong C-C bonds in cyclopropane (1)</p> <p><b>Or</b></p> <p>as a lot of energy is required to break the strong C-C bonds in cyclopropane (1)</p> <p>so the reaction requires very high temperatures (1)</p>	<p>Comment – alternative approach</p> <p>Allow TE from (a)(iii) for a small positive value (less than 50); the value is small so not much energy is required (1)</p> <p>the bonds in cyclopropane are strained/ C-C-C bond angle is 60° rather than 109.5° (1)</p> <p>Ignore any references to catalysts</p>	2

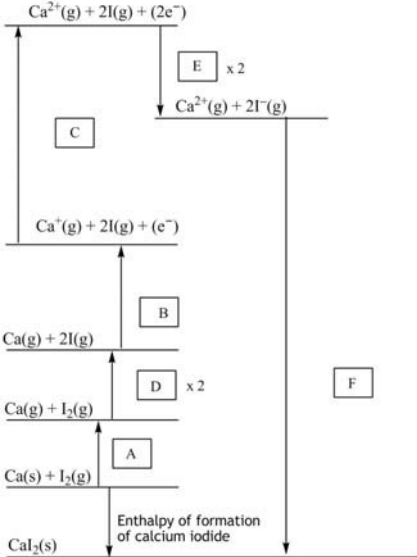
Question Number	Acceptable Answers	Additional Guidance	Mark
18(c)	<p>As <math>T</math> increases <math>k</math> increases (rapidly) (1)</p> <p>As the (average) energy of molecules / particles increases (1)</p> <p>So a greater proportion of / more collisions have energy <math>\geq</math> activation energy / (1)</p>	<p>Ignore any reference to equilibrium constant</p> <p>Ignore so a greater proportion of collisions are successful</p>	3

(Total for Question 18 = 12 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
19(a)(i)	<p><b>M1</b> Expression for <math>\Delta S_{\text{system}}</math> (1)</p> <p><b>M2</b> Value for <math>\Delta S_{\text{system}}</math> (1)</p> <p><b>M3</b> Expression for <math>\Delta S_{\text{surroundings}}</math> (1)</p> <p><b>M4</b> Value for <math>\Delta S_{\text{surroundings}}</math> (1)</p> <p><b>M5</b> Value for <math>\Delta S_{\text{total}}</math> to 2 or 3 SF and units (1)</p>	<p>Example of calculation:  <math>(186.2 + 239.7) - (16.5 + (4 \times 186.8))</math></p> <p><math>-337.8 \text{ J K}^{-1} \text{ mol}^{-1}</math></p> <p><math>\Delta S_{\text{surroundings}} = \frac{-\Delta H}{T} = -(-631.3 \times 10^3) / 298</math></p> <p><math>= (+) 2118.5 \text{ J K}^{-1} \text{ mol}^{-1} / (+) 2.1185 \text{ (kJ K}^{-1} \text{ mol}^{-1})</math></p> <p><math>(= 2118.5 + (- 337.8))</math></p> <p><math>= (+) 1780.7</math></p> <p><math>= (+) 1780 / (+) 1800 \text{ J K}^{-1} \text{ mol}^{-1}</math>  <math>(+) 1.78 / (+) 1.80 \text{ kJ K}^{-1} \text{ mol}^{-1}</math></p> <p>Allow TE at each stage                      Correct answer with no working scores 5</p> <p><math>(+) 2340 \text{ J K}^{-1} \text{ mol}^{-1}</math> scores 4 (1 x 186.8)  <math>(+) 2460 \text{ J K}^{-1} \text{ mol}^{-1}</math> scores 3 (react-prod)</p>	5

Question Number	Acceptable Answers	Additional Guidance	Mark
19(a)(ii)	<p>An answer that makes reference to:</p> <ul style="list-style-type: none"> <li>• A higher temperature would result in a less positive / lower <math>\Delta S_{\text{surroundings}}</math> (<math>\Delta S_{\text{system}}</math> is relatively unaffected by temperature) (1)</li> <li>• So <math>\Delta S_{\text{total}}</math> is less positive / lower, which makes reaction less feasible / reduces yield (1)</li> </ul> <p>COMMENT: For M1 and M2 allow correct calculation of <math>\Delta S_{\text{total}}</math> (at 973K) &gt; 0 to show that the reaction is feasible.</p> <ul style="list-style-type: none"> <li>• but high temperature is used to increase rate (1)</li> </ul>	<p>Ignore references to Le Chatelier for M1 and M2.</p> <p>Allow A higher temperature would result in an insignificant change in <math>\Delta S_{\text{surroundings}}</math> as its value is so large (<math>\Delta S_{\text{system}}</math> is relatively unaffected by temperature)</p> <p>So <math>\Delta S_{\text{total}}</math> is unchanged (in sign), which means feasibility of reaction is unchanged Ignore less easily / readily</p> <p>Standalone mark</p>	3

Question Number	Acceptable Answers	Additional Guidance	Mark
19(a)(iii)	Recall of expression for $K$ (1)  Rearrangement of expression and calculation of $\ln K$ and value for $K$ (1)  <b>Allow TE from (a)(i) but no TE if incorrect expression given in M1.</b>	Example of calculation: $\Delta S_{\text{total}} = R \ln K$  $\ln K = \Delta S_{\text{total}} / R = 1780.7 / 8.31$ $= 214.1998$  $1.15440 \times 10^{93}$  Allow any answer between $1.06 \times 10^{93}$ and $1.18 \times 10^{94}$ Ignore any units; Ignore SF Correct answer with no working scores 2	<b>2</b>

Question Number	Acceptable Answers	Additional Guidance	Mark
19(b)(i)	<p>Arrows upwards for first and second ionisation energies for calcium and correct labels, B and C in boxes (1)</p> <p>Downward arrows for electron affinity and lattice enthalpy and correct labels E x 2 and F in boxes (1)</p> <p>Correct species including state symbols on horizontal lines (1)</p> 	<p>Only penalise lack of arrow once in M1 and M2.</p> <p>If electrons are included, they must be correct but allow e<sup>-</sup></p>	3

Question Number	Acceptable Answers	Additional Guidance	Mark
<b>19(b)(ii)</b>	Correct expression (1)  Evaluation (1)	Example of calculation: [(178.2 + 590 + 1145 + (106.8 x 2) - (295.4 x 2)] - 2074  = -538 (kJ mol <sup>-1</sup> )  If E x 2 penalised in b(i), allow use of 1 x 295.4 as TE. In this case only -242.6(kJ mol <sup>-1</sup> ) scores 2  However, if E x 2 not penalised in b(i) then penalise failure to multiply by 2 once only in b(ii)  -349.4(kJ mol <sup>-1</sup> ) scores 1 (misses both x 2) -242.6(kJ mol <sup>-1</sup> ) scores 1 (misses 2 x 295.4) -644.8 (kJ mol <sup>-1</sup> ) scores 1 (misses 2 x 106.8) +538 (kJ mol <sup>-1</sup> ) scores 1 (expression wrong way round) ignore SF except 1 SF	<b>2</b>



Question Number	Acceptable Answers	Additional Guidance	Marks
19(b)(iii)	<p>Bonding in calcium fluoride is (virtually) 100% ionic (1)</p> <p>Whereas bonding in calcium iodide has a degree of covalency / somecovalent character (1)</p> <p>Then any <b>2</b> from these 3 marking points</p> <p>The calcium <b>ion</b> is polarising (1)</p> <p>The fluoride (ion) is small so not easily polarised / electron cloud not soeasily distorted (1)</p> <p>the iodide (ion) is larger and so is easily polarised / electron cloud iseasily distorted (1)</p>	<p>Allow Iodide / I<sup>-</sup> has some covalent character</p> <p>Penalise the use of fluorine and iodine once only</p>	<b>4</b>

Question Number	Acceptable Answers	Additional Guidance	Mark
19(c)	<p><b>M1</b> More exothermic / more negative / greater in magnitude (1)</p> <p><b>M2</b> As (the atomic radius of) chlorine is smaller / less shielding between nucleus and electron (to be gained) / chlorine has fewer shells (of electrons) (1)</p> <p><b>M3</b> Stronger attraction (between nucleus and electron to be gained) (1)</p>	<p>Ignore larger / less / higher Allow 'more energy released'</p> <p>Do not award chloride for chlorine</p> <p>Allow chlorine is more electronegative than iodine</p> <p>Allow reverse argument for M2 and M3</p>	3

(Total for Question 19 = 22 marks) (Total  
for Section B = 50 marks)

Section C

Question Number	Acceptable Answers	Additional Guidance	Mark
20(a)(i)	3-methylbutyl ethanoate or 3-methyl-1-butyl ethanoate	Allow butanyl for butyl Do not award butanoyl Allow methyl formethyl	1

Question Number	Acceptable Answers	Additional Guidance	Mark
20(a)(ii)	<ul style="list-style-type: none"> <li>• Calculation of <math>M_r</math> of ester (1)</li> <li>• Calculation of mass of ester (1)</li> <li>• Calculation of percentage of ester (1)</li> </ul>	<p><u>Example of calculation</u></p> <p><math>M_r</math> of ester = 130</p> <p>Mass of ester = <math>6.06 \times 10^{-3} \times 130</math> = 0.7878 (g)</p> <p>TE on incorrect <math>M_r</math> of ester</p> <p>% of ester = <math>(0.7878/1.07) \times 100 = 73.6\%</math> Allow 73.8% as M2 rounded to 0.79 Correct answer with no working scores 3 marks. Allow TE from M2 Ignore SF except 1SF</p>	3

Question Number	Acceptable Answers	Additional Guidance	Mark
20(a)(iii)	<ul style="list-style-type: none"> <li>Calculation of mol of excess sodium hydroxide (1)</li> <li>Calculation of concentration of excess sodium hydroxide (1)</li> <li>Calculation of pH to at least 1 dp (1)</li> </ul>	<p><u>Example of calculation</u>                      Excess amount of sodium hydroxide = <math>(0.025 \times 0.980) - 6.06 \times 10^{-3} = 0.01844</math> (mol)</p> <p>Concentration of excess sodium hydroxide = <math>0.01844/0.025 = 0.7376</math> (mol dm<sup>-3</sup>) allow TE from M1 if some attempt at subtraction</p> <p>pH = <math>14 - (-\log(0.7376)) = 13.8678 = 13.9</math></p> <p>allow TE from M2 if pH is greater than 7 and less than or equal to 14                      Allow 1 mark for pH = 13.99 (based on 0.98 mol dm<sup>-3</sup> NaOH)</p>	3

Question Number	Acceptable Answers	Additional Guidance	Mark
20(a)(iv)	<ul style="list-style-type: none"> <li>student C is correct as the titration is between a strong acid and a strong base (1)</li> <li>Both methyl orange and phenolphthalein change colour at equivalence / vertical section of the graph (1)</li> </ul>	<p>Allow A and B are incorrect</p> <p>Allow both pK<sub>IN</sub> values / range of indicators are within vertical section (of the graph)                      If values are quoted they must be correct PP = 9.3 ; MO = 3.7</p>	2

Question Number	Acceptable Answers	Additional Guidance	Mark
20(a)(v)	Add (excess) HCl(aq) (1)	Allow 'add a strong acid' Allow name or formula of any strong acid but if both are given, both must be correct  Ignore references to dilute / conc / heat / reflux	1

Question Number	Acceptable Answers	Additional Guidance	Mark
20(b)(i)	<p><b>M1</b> Calculates moles of CH<sub>3</sub>COONa/ NaOH (1)</p> <p><b>M2</b> Calculates moles of excess CH<sub>3</sub>COOH (1)</p> <p><b>M3</b> Calculates / shows ratio of [CH<sub>3</sub>COOH] to [CH<sub>3</sub>COONa] OR ratio of moles CH<sub>3</sub>COOH to CH<sub>3</sub>COONa (1)</p> <p><b>M4</b> re-arranges <math>K_a</math> or <math>pK_a</math> expression correctly and substitutes appropriate values to find <math>[H^+]</math> (1)</p> <p><b>M5</b> Calculation of pH (1)</p>	<p><u>Example of calculation</u>                      Moles of NaOH = moles of CH<sub>3</sub>COONa = (30/1000) x 0.142 = 4.26 x 10<sup>-3</sup> (mol)</p> <p>Moles of excess CH<sub>3</sub>COOH = [(50/1000) x 0.15] - 4.26 x 10<sup>-3</sup> = 3.24 x 10<sup>-3</sup> (mol)</p> <p>[CH<sub>3</sub>COOH] = 3.24 x 10<sup>-3</sup> / (80/1000) = 0.0405 (mol dm<sup>-3</sup>)</p> <p>[CH<sub>3</sub>COONa] = 4.26 x 10<sup>-3</sup> / (80/1000) = 0.05325 (mol dm<sup>-3</sup>)</p> <p>□ 0.0405 / 0.05325</p> <p>Allow ratio using moles as V cancels</p> <p>NOTE can be subsumed in M4</p> <p>[H<sup>+</sup>] = 1.70 x 10<sup>-5</sup> x (0.0405/0.05325) = 1.29 x 10<sup>-5</sup> (mol dm<sup>-3</sup>)</p> <p>Or</p> <p>pH = pK<sub>a</sub> - log([acid]/[base]) /</p> <p>pH = 4.77 - log (0.0405/0.05325)</p> <p>pH = 4.89</p> <p>Correct answer with no working scores 5 marks                      Ignore SF except 1SF                      Allow TE throughout                      Comment 4.52 will score 4 (omission of subtraction)</p>	5

Question Number	Acceptable Answers	Additional Guidance	Mark
20(b) (ii)	<p><b>M1</b> (Large) 'reservoir' of <math>\text{CH}_3\text{COOH}</math> and <math>\text{CH}_3\text{COO}^-</math> (1)</p> <p><b>M2</b> The <math>\text{OH}^-</math> ions react with <math>\text{CH}_3\text{COOH} / \text{H}^+</math> ions (1)</p> <p><b>M3</b> <math>\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}</math> or <math>\text{CH}_3\text{COOH} + \text{OH}^- \rightarrow \text{CH}_3\text{COO}^- + \text{H}_2\text{O}</math> (1)</p> <p><b>M4</b> The <math>\text{H}^+</math> ions react with <math>\text{CH}_3\text{COO}^-</math> or <math>\text{H}^+ + \text{CH}_3\text{COO}^- \rightleftharpoons \text{CH}_3\text{COOH}</math> (1)</p> <p><b>M5</b> The ratio of acid to base remains (almost) constant (1)</p>	<p>If both equations given both must be correct</p> <p>If equation given must be correct</p> <p>Allow base/salt remains (almost) constant Allow <math>[\text{H}^+]</math> remains(almost) constant</p>	5

(Total for Question 20 = 20 marks)

(Total for Section C = 20 marks)

Total for Paper = 90marks

