



## Mark Scheme (Results)

October 2018

Pearson Edexcel International  
Advanced Level  
In Chemistry (WCH04)  
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.

## 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 (multiple choice)**

Question Number	Correct Answer	Reject	Mark
<b>1</b>	<p>The only correct answer is <b>C</b></p> <p><i>A is not correct because rate constants always have units</i></p> <p><i>B is not correct because this shows the units of a first order reaction</i></p> <p><i>D is not correct because this shows the units of a second order reaction</i></p>		1

Question Number	Correct Answer	Reject	Mark
<b>2</b>	<p>The only correct answer is <b>B</b></p> <p><i>A is not correct because there is no change in the numbers of moles of gas in the reaction</i></p> <p><i>C is not correct because the reaction is in aqueous solution</i></p> <p><i>D is not correct because the reaction is in aqueous solution</i></p>		1

Question Number	Correct Answer	Reject	Mark
<b>3</b>	<p>The only correct answer is <b>A</b></p> <p><i>B is not correct because this is the shape of the graph of [reactant] v time for a first order reaction</i></p> <p><i>C is not correct because this shows rate decreasing with increasing [reactant]</i></p> <p><i>D is not correct because this is the shape of the graph of [product] v time for a first order reaction</i></p>		1

Question Number	Correct Answer	Reject	Mark
<b>4</b>	<p>The only correct answer is <b>C</b></p> <p><b>A</b> is not correct because <math>\Delta S_{\text{system}}</math> is expected to be negative as three moles of gas becomes two moles of gas</p> <p><b>B</b> is not correct because <math>\Delta S_{\text{system}}</math> is expected to be negative as three moles of gas becomes two moles of gas and <math>\Delta S_{\text{surroundings}}</math> must be positive as the reaction is exothermic</p> <p><b>D</b> is not correct because <math>\Delta S_{\text{surroundings}}</math> must be positive as the reaction is exothermic</p>		1

Question Number	Correct Answer	Reject	Mark
<b>5</b>	<p>The only correct answer is <b>B</b></p> <p><b>A</b> is not correct because this is irrelevant to the entropy of a substance</p> <p><b>C</b> is not correct because these are the conditions for the standard enthalpy of formation of an element</p> <p><b>D</b> is not correct because the molar entropy of a perfect crystal is not zero at the triple point</p>		1

Question Number	Correct Answer	Reject	Mark
<b>6</b>	<p>The only correct answer is <b>D</b></p> <p><b>A</b> is not correct because all gases mix regardless of their densities</p> <p><b>B</b> is not correct because these correct values have no bearing on the mixing process</p> <p><b>C</b> is not correct because the energy change is approximately zero.</p>		1

Question Number	Correct Answer	Reject	Mark
<b>7</b>	<p>The only correct answer is <b>C</b></p> <p><b>A</b> is not correct because <math>R \ln K = \Delta S_{\text{total}}</math></p> <p><b>B</b> is not correct because <math>R \ln K = \Delta S_{\text{total}}</math></p> <p><b>D</b> is not correct because <math>R \ln K = \Delta S_{\text{total}}</math></p>		1

Question Number	Correct Answer	Reject	Mark
<b>8</b>	<p>The only correct answer is <b>C</b></p> <p><i>A is not correct because water is in the gas state so <math>p(\text{H}_2\text{O}(g))</math> must be included in the <math>K_p</math> expression</i></p> <p><i>B is not correct because the expression is inverted and <math>p(\text{H}_2\text{O}(g))</math> has been omitted</i></p> <p><i>D is not correct because this is the <math>K_p</math> expression for the reverse reaction</i></p>		1

Question Number	Correct Answer	Reject	Mark
<b>9</b>	<p>The only correct answer is <b>D</b></p> <p><i>A is not correct because equilibrium is reached before time <math>t</math></i></p> <p><i>B is not correct because the concentrations continue to change after time <math>t</math></i></p> <p><i>C is not correct because the concentrations continue to change after time <math>t</math></i></p>		1

Question Number	Correct Answer	Reject	Mark
<b>10</b>	<p>The only correct answer is <b>A</b></p> <p><i>B is not correct because water will have the smaller iodine concentration</i></p> <p><i>C is not correct because water will be the upper layer</i></p> <p><i>D is not correct because water will be the upper layer and have the smaller iodine concentration</i></p>		1

Question Number	Correct Answer	Reject	Mark
<b>11</b>	<p>The only correct answer is <b>A</b></p> <p><i>B is not correct because <math>\text{NH}_2^-</math> is a base</i></p> <p><i>C is not correct because <math>\text{NH}_2^-</math> is a base</i></p> <p><i>D is not correct because <math>\text{NH}_3</math> is an acid also</i></p>		1

Question Number	Correct Answer	Reject	Mark
<b>12</b>	<p>The only correct answer is <b>B</b></p> <p><i>A is not correct because the pH is 7.1</i></p> <p><i>C is not correct because water is not alkaline</i></p> <p><i>D is not correct because water is not alkaline.</i>  <math>7.2 = \log(6.4 \times 10^{-15}) - 7.0</math></p>		1

Question Number	Correct Answer	Reject	Mark
<b>13</b>	<p>The only correct answer is <b>B</b></p> <p><i>A is not correct because the degree of dissociation increases with dilution</i></p> <p><i>C is not correct because the solution becomes less acidic and the degree of dissociation increases with dilution</i></p> <p><i>D is not correct because the solution becomes less acidic with dilution</i></p>		1

Question Number	Correct Answer	Reject	Mark
<b>14</b>	<p>The only correct answer is <b>B</b></p> <p><b>A</b> is not correct because <math>13.0 = pK_w + \log_{10}[\text{Ba}(\text{OH})_2]</math></p> <p><b>C</b> is not correct because <math>13.8 = pK_w - 2x[\text{Ba}(\text{OH})_2]</math></p> <p><b>D</b> is not correct because <math>13.9 = pK_w - [\text{Ba}(\text{OH})_2]</math></p>		1

Question Number	Correct Answer	Reject	Mark
<b>15</b>	<p>The only correct answer is <b>A</b></p> <p><i>B is not correct because pure propanone does not form hydrogen bonds</i></p> <p><i>C is not correct because while propanone forms stronger London forces than butane this is insufficient to account for the difference</i></p> <p><i>D is not correct because although this is correct it does not account for the difference</i></p>		1

Question Number	Correct Answer	Reject	Mark
<b>16</b>	<p>The only correct answer is <b>B</b></p> <p><i>A is not correct as copper is not formed with ethanal</i></p> <p><i>C is not correct as copper is not formed with ethanal and the ethanal is oxidised not reduced</i></p> <p><i>D is not correct as the ethanal is oxidised not reduced</i></p>		1

Question Number	Correct Answer	Reject	Mark
<b>17</b>	<p>The only correct answer is <b>D</b></p> <p><i>A is not correct because this would form ethanol</i></p> <p><i>B is not correct because this would form ethanol</i></p> <p><i>C is not correct because this would form ethanoic acid</i></p>		1

Question Number	Correct Answer	Reject	Mark
<b>18</b>	<p>The only correct answer is <b>D</b></p> <p><i>A is not correct because propyl methanoate forms methanoic acid and ethanenitrile forms ethanoic acid</i></p> <p><i>B is not correct because propyl methanoate forms methanoic acid</i></p> <p><i>C is not correct because ethanenitrile forms ethanoic acid</i></p>		1

Question Number	Correct Answer	Reject	Mark
<b>19</b>	<p>The only correct answer is <b>A</b></p> <p><i>B is not correct because this is not formed</i></p> <p><i>C is not correct because this is not formed</i></p> <p><i>D is not correct because this is not formed</i></p>		1

Question Number	Correct Answer	Reject	Mark
<b>20</b>	The only correct answer is <b>C</b>  <i>A is not correct because radio waves have insufficient energy to initiate reactions</i>  <i>B is not correct because radio waves have insufficient energy to initiate reactions</i>  <i>D is not correct because ultraviolet radiation does initiate organic reactions</i>		1

**(Total for Section A = 20 marks)**



Question Number	Acceptable Answers	Reject	Mark
<b>21(c)</b>	$\Delta S_{\text{surroundings}} = \frac{-\Delta H_{\text{reaction}}}{T}$ $= -(-42600)/298 \quad (1)$ $= (+)142.953 / 143 \text{ (J K}^{-1} \text{ mol}^{-1}) \quad (1)$ OR $= -(-42.6)/298 \quad (1)$ $= (+)0.142953 \text{ (J K}^{-1} \text{ mol}^{-1})$ $/ (+)0.143 \text{ kJ K}^{-1} \text{ mol}^{-1} \quad (1)$ <p>Doubling the value (giving (+)285.906 (J K<sup>-1</sup> mol<sup>-1</sup>) / (+)0.285906 <b>kJ K<sup>-1</sup> mol<sup>-1</sup></b> scores (1) unless already penalised in (b)</p> $-0.142953 / 0.143 \text{ kJ K}^{-1} \text{ mol}^{-1}$ scores (1) IGNORE SF except 1 SF Correct answer (with units if 0.142953) scores (2)	incorrect units  incorrect units	2

Question Number	Acceptable Answers	Reject	Mark
<b>21(d)</b>	$\Delta S_{\text{total}} = \Delta S_{\text{system}} + \Delta S_{\text{surroundings}}$ $= 536.2 + 142.953 \quad (1)$ $= (+)679.153 \text{ (J K}^{-1} \text{ mol}^{-1}) \quad (1)$ OR $= 0.5362 + 0.142953 \quad (1)$ $= (+)0.679153 \text{ kJ K}^{-1} \text{ mol}^{-1} \quad (1)$ <p>No TE on incorrect expression</p> <p>IGNORE SF except 1 SF</p> <p>Correct answer scores (2)            TE on (b) and (c) unless final value is negative when max 1 mark</p> <p>Value with <math>\Delta S_{\text{surroundings}}</math> doubled =            (+)822.106 (J K<sup>-1</sup> mol<sup>-1</sup>) /            (+)0.822106 (kJ K<sup>-1</sup> mol<sup>-1</sup>) scores (2)            Value from <math>\Delta S_{\text{system}} = +248.8 \text{ J K}^{-1} \text{ mol}^{-1}</math>  <b>mol<sup>-1</sup> is</b>  <b>391.75 (J K<sup>-1</sup> mol<sup>-1</sup>) / 0.39175 (kJ K<sup>-1</sup> mol<sup>-1</sup>)</b> </p>		2

Question Number	Acceptable Answers	Reject	Mark
<b>21(e)</b>	<p>The (molar) entropy of a substance (always) increases / becomes more positive with (increasing) temperature  ALLOW  The (molar) entropy of a gas increases the most with (increasing) temperature (1)</p> <p>There are more moles of product than of reactant  OR  3 mol of gas are formed (from a solid)  OR  Na changes from solid to liquid (1)  so <math>\Delta S_{\text{system}}</math> must increase (1)</p> <p>MP3 dependent on <b>MP1</b> being scored</p> <p>If no other mark is scored, '<math>\Delta S_{\text{system}}</math> increases because increasing temperature increases the disorder of the system / reaction' scores (1)</p> <p>IGNORE  Explanations based on <math>K_c</math> or Le Chatelier  OR  Based on the change in <math>\Delta S_{\text{surroundings}}</math> with temperature</p>		3

(Total for Question 21 = 11 marks)

Question Number	Acceptable Answers	Reject	Mark
<b>22(a)(i)</b>	<p><b>MP1</b> Explanation of <math>K_{a1}</math> values</p> <p><math>K_{a1} \gg K_{a2}</math> or <math>pK_{a1} \ll pK_{a2}</math> so first ionisation / dissociation is much greater than second ionisation / dissociation</p> <p>ALLOW</p> <p><math>pK_{a2}</math> larger (than <math>pK_{a1}</math>)  <b>and</b> so <math>K_{a2}</math> smaller (than <math>K_{a1}</math>)</p> <p>OR</p> <p>As <math>pK_a</math> increases acid strength decreases (1)</p> <p><b>MP2</b> Effect of first dissociation</p> <p>(relatively) high <math>[H^+]</math> suppresses second / further ionisation / dissociation</p> <p>ALLOW</p> <p>First ionisation suppresses / weakens second ionisation</p> <p>OR</p> <p>Ionising / dissociating / removing a proton from a negative ion requires more energy / is more difficult (1)</p> <p>IGNORE</p> <p>Reference to 'weak acid'</p> <p>Reference to H-bonding</p> <p>Reference to third ionisation / dissociation</p>	<p>Reference to ionisation energy</p> <p>Alcohol OH ionises</p>	2

Question Number	Acceptable Answers	Reject	Mark
<b>22(a)(ii)</b>	<p><math>H_3A \rightleftharpoons H^+ + H_2A^-</math></p> <p>OR</p> <p><math>H_3A + H_2O \rightleftharpoons H_3O^+ + H_2A^-</math></p> <p>ALLOW</p> <p>Single headed arrow or '=' for <math>\rightleftharpoons</math></p> <p>IGNORE</p> <p>State symbols even if incorrect</p> <p><math>K_a</math> expression</p>		1

Question Number	Acceptable Answers	Reject	Mark
<b>22(a)(iii)</b>	$K_{a1} = [\text{H}^+][\text{H}_2\text{A}^-] / [\text{H}_3\text{A}] \quad (1)$ $= [\text{H}^+]^2 / [\text{H}_3\text{A}]$ $10^{-3.13} = (10^{-1.98})^2 / [\text{H}_3\text{A}] \quad (1)$ $[\text{H}_3\text{A}] = (10^{-1.98})^2 / 10^{-3.13}$ $= 0.14791$ $= 0.148 / 0.15 \text{ (mol dm}^{-3}\text{)} \quad (1)$ <p>IGNORE SF except 1 SF Correct answer with some correct working scores (3)</p> $[\text{H}_3\text{A}] = 0.1487 / 0.149 \text{ (mol dm}^{-3}\text{)}$ (from rounding 0.01047 to 0.0105) scores (3) $[\text{H}_3\text{A}] = 0.135 / 0.14 \text{ (from rounding 0.01047 to 0.01) scores (2)}$ $[\text{H}_3\text{A}] = 3.503 \times 10^{-5} / 0.0003503 \text{ (mol dm}^{-3}\text{)}$ from $K_{a1} = 3.13$ scores (2) <p>If no other mark is scored allow (1) for <math>[\text{H}^+] = 10^{-1.98}</math> <math>= 0.010471 / 0.0105 / 0.010 \text{ (mol dm}^{-3}\text{)}</math></p>	0.01 (mol dm <sup>-3</sup> )	3

Question Number	Acceptable Answers	Reject	Mark
<b>22(b)(i)</b>	The pulp could block (the tip of) the pipette OR The pipetted volume might be too <b>low</b>	Pulp causes side reactions / reacts with NaOH  Just 'causes blockages'	1

Question Number	Acceptable Answers	Reject	Mark
<b>22(b)(ii)</b>	Phenolphthalein OR Thymol blue (base) / 8.0–9.6 OR Thymolphthalein ALLOW Phenol red (1)  Indicator range should cover roughly the mid-point of 6.4 ( $=pK_{a3} = \text{pH of second buffer region}$ ) and 13 (pH of NaOH) OR Indicator range mid-point needs to be about 2 units above 6.4 ALLOW Indicator range needs to be from 6.5–8.0 to 10–13 (1)  IGNORE Weak acid-strong base titration General statements about the vertical section of the titration curve Statement of selected indicator's range	Just 'thymol blue'	2

Question Number	Acceptable Answers	Reject	Mark
<b>22(b)(iii)</b>	<p><b>MP1</b> Calculates moles NaOH  <math>= 0.095 \times 19.65 \times 10^{-3}</math>  <math>= 1.86675 \times 10^{-3} / 0.00186675 \text{ (mol) (1)}</math></p> <p><b>MP2</b> Calculates moles citric acid  <math>= \text{mol NaOH} \div 3</math>  <math>= 6.2225 \times 10^{-4} / 0.00062225 \text{ (mol) (1)}</math></p> <p><b>MP3</b> Scales mol citric acid to 250 cm<sup>3</sup> (x 10)  <b>and</b> scales <b>original</b> volume of lemon juice to 1 dm<sup>3</sup> (x 1000/25)  <math>= \text{answer to MP2} \times 10 \times 40 = 0.2489 \text{ mol dm}^{-3} \text{ (1)}</math></p> <p><b>MP4</b> Calculates molar mass of citric acid  molar mass (citric acid)  <math>= 6 \times 12 + 8 + 7 \times 16 = 192 \text{ (1)}</math></p> <p><b>MP5</b> Calculates concentration of citric acid  <math>= \text{molar mass of citric acid} \times \text{answer to MP3}</math>  <math>= 192 \times 0.2489 = 47.7888 \text{ (g dm}^{-3}\text{) (1)}</math></p> <p>IGNORE SF except 1 SF</p> <p>TE at each stage  Correct answer with no working scores (5)  143.37 (g dm<sup>-3</sup>) [<b>MP2</b> incorrect] scores 4</p> <p><b>COMMENT</b>  ALLOW  <b>MP5</b> for multiplying the calculated <math>M_r</math> by  <b>MP2</b> OR <b>MP2</b> x 10 or <b>MP2</b> x 40  Note that all the scaling is in <b>MP3</b></p>	Just a number x $M_r$	5

Question Number	Acceptable Answers	Reject	Mark
<b>22(b)(iv)</b>	The citric acid content / amount / concentration varies for different lemons	Reference to errors and uncertainties in the procedure.	1

Question Number	Acceptable Answers	Reject	Mark
<b>22(c)(i)</b>	<p>A buffer resists change in pH OR Maintains a <b>fairly / nearly</b> constant pH ALLOW 'large / small change' for 'change' 'withstands change in pH' (1)</p> <p>on the addition of <b>small</b> amounts of acid <b>and / or</b> of alkali ALLOW Base / OH<sup>-</sup> for alkali and H<sup>+</sup> for acid (1)</p>	<p>Keeps pH constant pH remains the same prevents change in pH</p>	2

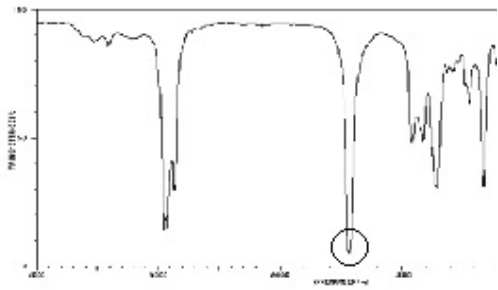
Question Number	Acceptable Answers	Reject	Mark
<b>22(c)(ii)</b>	<p>3.13 OR pH = 3.13 OR pH = pK<sub>a1</sub> = 3.13</p>	pK <sub>a1</sub> = 3.13	1

Question Number	Acceptable Answers	Reject	Mark
<b>22(c)(iii)</b>	<p>Allow use of <math>C_6H_7O_7Na</math> for <math>C_6H_7O_7^-</math> throughout</p> <p><b>MP1</b> Citric acid / <math>C_6H_8O_7</math> and dihydrogen citrate / <math>C_6H_7O_7^-</math> are present in high concentration (and so their values do not change significantly when small amounts of acid or alkali are added) ALLOW 'large amount' / '(large) excess' for high concentration (Large) reservoir of <math>C_6H_8O_7</math> and <math>C_6H_7O_7^-</math> OR reservoir of <math>C_6H_8O_7</math> and its conjugate base (1)</p> <p><b>MP2</b> When acid is added the <math>C_6H_7O_7^-</math> is protonated / reacts, removing the <math>H^+</math> ion from the solution ALLOW <math>C_6H_7O_7^- + H^+ \rightarrow C_6H_8O_7</math> (1)</p> <p><b>MP3</b> When alkali is added the <math>C_6H_8O_7</math> is deprotonated / reacts, removing the <math>OH^-</math> ion from the solution ALLOW <math>C_6H_8O_7 + OH^- \rightarrow C_6H_7O_7^- + H_2O</math> (1)</p> <p><b>MP2 and MP3</b> may be scored by <b>referring</b> to the equilibrium <math>C_6H_7O_7^- + H^+ \rightleftharpoons C_6H_8O_7</math></p> <p>Use of HA and <math>A^-</math> or general 'weak acid and salt' scores <b>MP2</b> and <b>MP3</b> only</p> <p>IGNORE Reference to ratio of <math>C_6H_8O_7</math> and <math>C_6H_7O_7^-</math> concentrations</p>		3

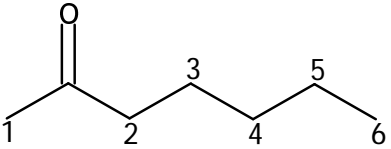
(Total for Question 22 = 21 marks)

Question Number	Acceptable Answers	Reject	Mark
<b>23(a)</b>	Brady's reagent OR 2,4-dinitrophenylhydrazine  ALLOW 2,4-DNPH / 2,4-DNP / DNPH (1)  Red /orange / yellow <b>and</b> precipitate (forms in both cases) ALLOW ppt / ppte / solid / crystals for precipitate  (1) Observation mark depends on correct reagent or near miss (e.g. DNHP)	Incorrect abbreviation e.g. DNHP / DPNH  solution	2

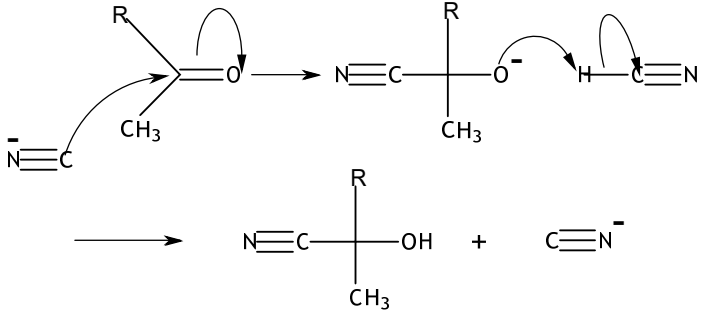
Question Number	Acceptable Answers	Reject	Mark
<b>23(b)</b>	(Warm with) iodine and sodium hydroxide OR (Warm with) potassium iodide and sodium chlorate(I) ALLOW iodine in alkali / I <sub>2</sub> and OH <sup>-</sup> (1)  With heptan-2-one Antiseptic smell observed OR (Pale) yellow crystals form ALLOW precipitate / ppt / ppte / solid / suspension for crystals (1)  With heptan-3-one No (observed) change ALLOW no reaction / observation / negative result (1)  No TE on any other test but if 'iodoform test' stated, MP2 and MP3 may be awarded.  IGNORE Physical tests including on derivatives	Just 'smell'          Brown solution	3

Question Number	Acceptable Answers	Reject	Mark
<b>23(c)(i)</b>	 <p>Carbonyl peak circled ALLOW Any means of selecting this peak (1) Carbonyl group / C=O (responsible) (1) These marks are standalone</p>	Just 1700–1680 (cm <sup>-1</sup> )	2

Question Number	Acceptable Answers	Reject	Mark
<b>23(c)(ii)</b>	<p>Yes because the IR spectra of the isomers would have different fingerprint regions. OR Yes by comparing the spectrum to reference spectra.</p> <p>ALLOW No because they have the same functional group / bonds OR Both are ketones</p> <p>IGNORE Just 'spectra would be different' OR 'Spectra have different peaks'</p>		1

Question Number	Acceptable Answers	Reject	Mark
<b>23(d)(i)</b>			1

Question Number	Acceptable Answers	Reject	Mark																					
<b>23(d)(ii)</b>	<table border="1" data-bbox="438 619 1039 1102"> <thead> <tr> <th>Proton environment</th> <th>Relative peak area</th> <th>Splitting pattern</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>3</td> <td>singlet</td> </tr> <tr> <td>2</td> <td>2</td> <td>triplet</td> </tr> <tr> <td>3</td> <td>2</td> <td>quintet</td> </tr> <tr> <td>4</td> <td>2</td> <td>quintet</td> </tr> <tr> <td>5</td> <td>2</td> <td>sextet</td> </tr> <tr> <td>6</td> <td>3</td> <td>triplet</td> </tr> </tbody> </table> <p>All relative peak areas correct (1)            IGNORE            Any peak area for the carbonyl carbon</p> <p>All splitting patterns correct (2)            Four or five splitting patterns correct scores (1)            If the carbonyl carbon has been labelled as a proton environment, correct splitting pattern for 3, 4, 5 and 6 scores (1)</p> <p>ALLOW            Use of non-standard terms for splitting e.g. 1 for singlet etc            '3 splits', 'pentate' / 'pentet' / 'pentlet'</p>	Proton environment	Relative peak area	Splitting pattern	1	3	singlet	2	2	triplet	3	2	quintet	4	2	quintet	5	2	sextet	6	3	triplet		3
Proton environment	Relative peak area	Splitting pattern																						
1	3	singlet																						
2	2	triplet																						
3	2	quintet																						
4	2	quintet																						
5	2	sextet																						
6	3	triplet																						

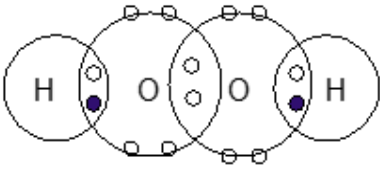
Question Number	Acceptable Answers	Reject	Mark
<b>23(e)(i)</b>	 <p>All four curly arrows correct</p> <p>ALLOW curly arrow from any part of <math>\text{CN}^-</math> including from the charge (2)</p> <p>Intermediate (1)</p> <p>Both final products (1)</p> <p>Mechanism with curly arrow from intermediate to <math>\text{H}^+</math> and formation of cyanohydrin only scores (3)</p> <p>Any two or three correct curly arrows scores 1</p> <p>Curly arrows must start and finish reasonably close to the relevant atoms / bonds</p> <p>If the nucleophilic attack is in two stages (via <math>^+\text{C}-\text{O}^-</math>) do not award the intermediate mark (max 3)</p> <p>Dipoles are not required but if shown must be correct</p> <p>CN bond does not need to be displayed</p> <p>Lone pairs are not required</p> <p>Penalise omission of charges once only</p>	<p><math>\text{CN}^-</math> charge omitted</p>	4

Question Number	Acceptable Answers	Reject	Mark
<b>23(e)(ii)</b>	<p>A racemic mixture is formed (1)</p> <p>heptan-2-one is planar <b>and</b> about the carbonyl carbon ALLOW Bonds about C=O (trigonal) planar OR carbonyl carbon is (trigonal) planar (1)</p> <p>So the CN<sup>-</sup> attacks equally from above and below / either side of the molecule ALLOW Nucleophile / CN for CN<sup>-</sup> (1)</p>	ion / molecule is planar	3

**(Total for Question 23 = 19 marks)**

**(Total for Section B = 51 marks)**

### Section C

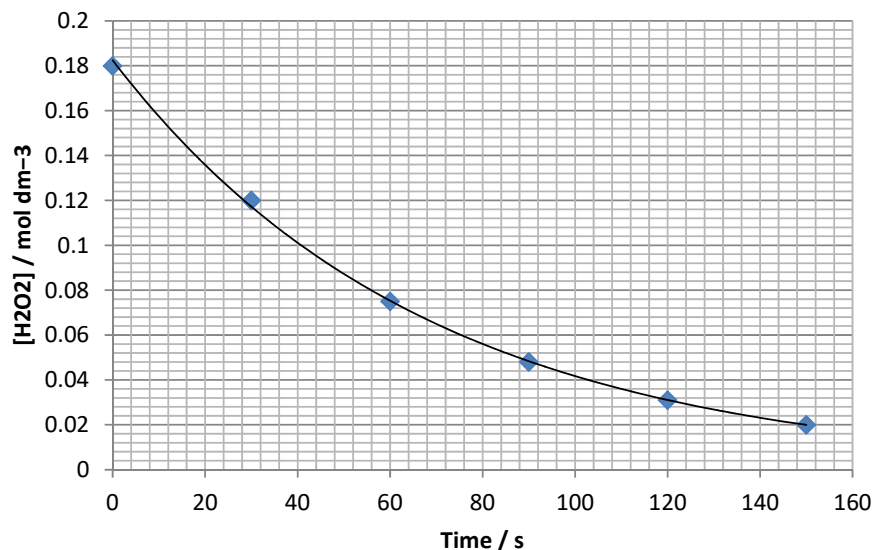
Question Number	Acceptable Answers	Reject	Mark
<b>24(a)</b>	 <p>ALLOW Any representation of the electrons, (including all electrons the same) Bond electrons horizontal (H x o O)</p> <p>IGNORE Bonds shown as lines Position of lone pairs H-O-O-H Omission of circles</p>		1

Question Number	Acceptable Answers	Reject	Mark
<b>24(b)</b>	<p>Any two from:</p> <p>Hydrogen peroxide has a bigger dipole (moment than water) / larger dipole-dipole forces ALLOW Hydrogen peroxide is more polar (than water) (1)</p> <p>Hydrogen peroxide has greater London / dispersion forces (than water) ALLOW van der Waals / vdW / induced dipole-induced dipole forces (1)</p> <p>Hydrogen peroxide forms a higher proportion of hydrogen bonds in its liquid state (than water) ALLOW Hydrogen peroxide forms more hydrogen bonds in its liquid state (than water) OR Hydrogen peroxide forms stronger hydrogen bonds (than water) (1)</p> <p>For more hydrogen bonds allow specified numbers e.g. hydrogen peroxide forms 2 but water forms 1</p> <p>The comparisons are required</p>		2

Question Number	Acceptable Answers	Reject	Mark
<b>24(c)</b>	<p>The oxygen- oxygen /O—O /peroxide (single) bond is weak</p> <p>ALLOW O=O is strong so the products are thermodynamically more stable</p> <p>IGNORE Entropy arguments</p>	Just 'weak bonds'	1

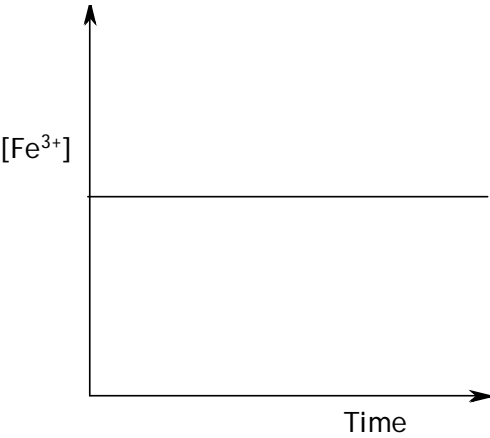
Question Number	Acceptable Answers	Reject	Mark
<b>24(d)(i)</b>	Add sample to (ice-cold) water  ALLOW Dilute sample in water	Addition of any chemical apart from H <sub>2</sub> O  Place in ice-bath	1

Question Number	Acceptable Answer	Reject	Mark
<b>24(d)(ii)</b>	See below for example  Sensible choice scale (to cover at least half the grid in both directions) <b>and</b> labelled axes with units on both axes ALLOW [] for [H <sub>2</sub> O <sub>2</sub> ] (1)  All points given in table correctly plotted Dependent on linear axes used (1)  Any sensible reasonably smooth best fit curve reasonably close to the points (1)	Non-linear scale scores (0)  point to point	3



Question Number	Acceptable Answers	Reject	Mark
<b>24(d)(iii)</b>	$t_{1/2}(1) = 47$ s $t_{1/2}(2) = 47$ s ALLOW 44-50 s Values may be shown on the graph No TE on a badly drawn line	no working shown	1

Question Number	Acceptable Answers	Reject	Mark
<b>24(d)(iv)</b>	<p>Because both values are the same / similar the reaction is first order (with respect to hydrogen peroxide)</p> <p>This mark may only be awarded if half lives in 24(d)(iii) are the same (within 6 seconds of each other) OR half lives are given as (e.g.) 47 and 94 s Allow this mark if only 1 correct half life is given in 24d(iii) but 2 structure lines are shown on the graph</p>	Just 'first order'	1

Question Number	Acceptable Answers	Reject	Mark
<b>24(d)(v)</b>	 <p>Any line parallel to the x axis</p>		1

Question Number	Acceptable Answers	Reject	Mark
<b>24(e)(i)</b>	<p>First order / order 1 <b>and</b> (e.g.) Because doubling / halving <math>[Fe^{3+}]</math> results in a doubling / halving of the rate OR Because tripling <math>[Fe^{3+}]</math> results in a tripling of the rate</p>		1

Question Number	Acceptable Answers	Reject	Mark
<b>24(e)(ii)</b>	<p>Rate / R = <math>k[H_2O_2][Fe^{3+}]</math></p> <p>TE on (d)(iv and (e)(i) Score (0) if these are blank</p>		1

Question Number	Acceptable Answers	Reject	Mark
<b>24(f)(i)</b>	<p>(e.g. from graph)</p> $\frac{1000 \times (6.98 - 5.86)}{-(3.55 - 3.15)} = -\frac{1.12}{0.40} \times 1000 \quad (1)$ $= -2.80 \times 10^3 \text{ (K)}$ <p>ALLOW  <math>-2.70 \times 10^3</math> to <math>-2.90 \times 10^3</math>            Answer as a fraction (1)</p> <p><math>-2.80 \times 10^{-3}</math> (K) / <math>-2.80</math> (K) (or values within the 2.70 - 2.90 range) score (1)</p> <p>Coefficient with correct sign and no units or correct units scores (1)            Correct magnitude scores (1)</p>	positive value Incorrect units	2

Question Number	Acceptable Answers	Reject	Mark
<b>24(f)(ii)</b>	<p>gradient = <math>-E_a/R</math>  <math>-2.80 \times 10^3 = -E_a/8.31 \quad (1)</math></p> <p><math>E_a = +23268 \text{ J mol}^{-1} / +23.268 \text{ kJ mol}^{-1}</math>            ALLOW  <math>22.4</math> to <math>24.1 \text{ kJ mol}^{-1} \quad (2)</math></p> <p>Value with sign (1) units (1)</p> <p>Units must be correct for the calculation done</p> <p>IGNORE SF except 1 SF</p> <p>TE on (f)(i) for value and sign</p> <p>If the answer to (f)(i) is positive then <math>E_a</math> has to be negative (even though this is chemically incorrect)            If 'kilo' prefix used even in an incorrect unit <math>8.31 \times</math> gradient must be divided by 1000 otherwise the value from (f)(i) <math>\times 8.31</math> scores the mark</p>		3

Question Number	Acceptable Answers	Reject	Mark
<b>24(g)</b>	Hydrogen peroxide decomposes to form (only) water / H <sub>2</sub> O <b>and</b> oxygen / O <sub>2</sub> (which are environmentally harmless)  IGNORE Forms harmless products		1

**(Total for Question 24 = 19 marks)**

**(Total for Section C = 19 marks)**

**(Total for Paper = 90 marks)**

