

# Mark Scheme (Results) January 2010

GCE

## GCE Chemistry (6CH04/01)

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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

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	Correct Answer	Reject	Mark
1	B		1

Question Number	Correct Answer	Reject	Mark
2	C		1

Question Number	Correct Answer	Reject	Mark
3	B		1

Question Number	Correct Answer	Reject	Mark
4	A		1

Question Number	Correct Answer	Reject	Mark
5	B		1

Question Number	Correct Answer	Reject	Mark
6	D		1

Question Number	Correct Answer	Reject	Mark
7	B		1

Question Number	Correct Answer	Reject	Mark
8	A		1

Question Number	Correct Answer	Reject	Mark
9	A		1

Question Number	Correct Answer	Reject	Mark
10	D		1

Question Number	Correct Answer	Reject	Mark
11	A		1

Question Number	Correct Answer	Reject	Mark
12	C		1

Question Number	Correct Answer	Reject	Mark
13	A		1

Question Number	Correct Answer	Reject	Mark
14	B		1

Question Number	Correct Answer	Reject	Mark
15	D		1

Question Number	Correct Answer	Reject	Mark
16	C		1

Question Number	Correct Answer	Reject	Mark
17	D		1

Question Number	Correct Answer	Reject	Mark
18	C		1

Question Number	Correct Answer	Reject	Mark
19	C		1

Question Number	Correct Answer	Reject	Mark
20	C		1

## Section B

Question Number	Acceptable Answers	Reject	Mark
21 (a)(i)	<p>(pH =) <math>-\log [\text{H}^+]</math></p> <p>OR</p> <p>(pH =) <math>-\log [\text{H}_3\text{O}^+]</math></p> <p>OR</p> <p><b>Accept</b>            Definition in words            (For example: "It is minus / negative log(arithm) of the hydrogen <b>ion</b> concentration")</p> <p>Base 10 does not have to be there, but reject "ln"</p>	<p><b>Just</b> "concentration of hydrogen ions"</p> <p>{ } curly brackets</p> <p><math>-\log \text{H}^+</math></p>	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
21 (a)(ii)	$(\text{pH} = -\log 0.0100) = 2(.00)$	If any units given	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
21 (b)(i)	<p><math>[H_3O^+] = \frac{K_a[CH_3COOH]}{[CH_3COO^-]}</math></p> <p>OR</p> <p><math>[H_3O^+]^2 = K_a[CH_3COOH] \quad (1)</math></p> <p><i>ALLOW</i></p> <p>[HA] for [CH<sub>3</sub>COOH] and [A<sup>-</sup>] for [CH<sub>3</sub>COO<sup>-</sup>] in rearranged expression</p> <p><b>Accept</b> [H<sup>+</sup>] for [H<sub>3</sub>O<sup>+</sup>]</p> <p><math>\therefore [H_3O^+] = \sqrt{1.75 \times 10^{-7}}</math></p> <p>OR</p> <p><math>\therefore [H_3O^+] = 4.18(3) \times 10^{-4} \text{ (mol dm}^{-3}\text{)} \quad (1)</math></p> <p>pH = 3.38 / 3.4 <span style="float: right;">(1)</span> ignore sf except one sf</p> <p>Third mark TE from [H<sup>+</sup>] only if pH less than 7</p> <p><b><i>N.B. CORRECT ANSWER, WITH OR WITHOUT WORKING, SCORES (3)</i></b></p> <p><b>Assumption</b> assumes that degree of ionisation of the acid is very small/negligible</p> <p>OR</p> <p><math>[CH_3COOH]_{eqm} = [CH_3COOH]_{initial}</math></p> <p>OR</p> <p><math>[H^+] = [CH_3COO^-]</math></p> <p>OR</p> <p>all of the hydrogen ions come from the acid / ignore hydrogen ions from the water <span style="float: right;">(1)</span></p> <p><b>IGNORE</b> any references to temperature</p>	<p>3.37 / 3 / 3.39 / a correct pH value <b>with units</b></p> <p>just “weak acid” / just “partially dissociates” / acid does not dissociate / [CH<sub>3</sub>COOH] constant</p> <p><math>[H^+] = [OH^-]</math> / <math>[H^+] = [\text{salt}]</math></p>	4

Question Number	Acceptable Answers	Reject	Mark
21 (b)(ii)	<p><b>First mark:</b></p> <p>(Dilution/addition of water) shifts the equilibrium</p> $\text{CH}_3\text{COOH} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}^+ /$ $\text{CH}_3\text{COOH} + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}_3\text{O}^+$ <p>to the <b>right</b> OR the above stated in words such as: degree of dissociation increases/ proportion of dissociation increases/ more dissociation (as the ethanoic acid is diluted) (1)</p> <p><b>Second mark:</b></p> <p>so the <math>[\text{H}^+]</math> is greater than expected/ so the decrease in <math>[\text{H}^+]</math> is less than expected / so that the decrease in <math>[\text{H}^+]</math> is less than that for hydrochloric acid (1)</p> <p><b>Each mark is a stand alone mark.</b></p> <p><i>ALTERNATIVE ROUTE:</i></p> <p><b>First mark:</b></p> $[\text{H}^+] = \sqrt{K_a \times [\text{HA}]} \text{ OR } (K_a \times [\text{HA}])^{1/2}$ <p>OR</p> $\text{pH} = \frac{1}{2}\text{p}K_a - \frac{1}{2}\log[\text{HA}]$ <p>(1)</p> <p><b>Second mark:</b></p> <p>use of mathematical expression given (e.g. <math>[\text{H}^+]</math> affected by factor of <math>1/\sqrt{10}</math> on dilution OR substitution of numerical values into the equation) (1)</p> <p><i>IGNORE:</i> any comments or calculations relating to HCl(aq)</p>	<p>Reject just a reference to a 0.5 increase in pH for CH<sub>3</sub>COOH(aq) compared with a 1.0 increase in pH for HCl(aq)</p>	2



Question Number	Acceptable Answers	Reject	Mark
21 (c)(i)	<p><b>These marks are stand alone.</b></p> <p>Maintains an <b>almost</b> constant pH / resists change(s) in pH (1)</p> <p>for <b>small</b> addition of H<sup>+</sup> or OH<sup>-</sup> ions (N.B. both ions needed) / for <b>small</b> additions of acid or alkali / for <b>small</b> additions of acid or base (1)</p> <p><i>IGNORE</i> any references to named buffer mixtures</p>	<p>“resists small change(s) in pH” OR “pH does not change”</p>	2

Question Number	Acceptable Answers	Reject	Mark
21 (c)(ii)	citric acid		1

Question Number	Acceptable Answers	Reject	Mark
21 (c)(iii)	<p><b>First mark:</b></p> <p>(buffer contains) reservoir of HA and A<sup>-</sup> OR (buffer contains) large concentrations of [HA] and [A<sup>-</sup>] OR <b>both equations:</b> HA <math>\rightleftharpoons</math> A<sup>-</sup> + H<sup>+</sup> and NaA <math>\rightarrow</math> Na<sup>+</sup> + A<sup>-</sup></p> <p style="text-align: right;"><b>(1)</b></p> <p><b>Second mark:</b></p> <p>(Addition of alkali/base)</p> <p>HA + OH<sup>-</sup> <math>\rightarrow</math> A<sup>-</sup> + H<sub>2</sub>O OR description/equations to show that H<sup>+</sup> reacts with OH<sup>-</sup> (to form H<sub>2</sub>O) and more acid dissociates (to replace H<sup>+</sup>)</p> <p style="text-align: right;"><b>(1)</b></p> <p><b>Third mark:</b></p> <p>(Addition of acid)</p> <p>A<sup>-</sup> + H<sup>+</sup> <math>\rightarrow</math> HA OR A<sup>-</sup> reacting with H<sup>+</sup> in any context described in words (e.g. by reference to weak acid equilibrium)</p> <p style="text-align: right;"><b>(1)</b></p> <p><b>Fourth mark:</b></p> <p>the ratio of [A<sup>-</sup>]:[HA] hardly changes / the ratio of [HA]:[A<sup>-</sup>] hardly changes OR [A<sup>-</sup>] nor [HA] changes <b>significantly (1)</b></p>	<p><b>JUST</b> NaA <math>\rightleftharpoons</math> Na<sup>+</sup> + A<sup>-</sup> and HA <math>\rightarrow</math> H<sup>+</sup> + A<sup>-</sup> without correct description</p> <p><b>Just [H<sup>+</sup>] remains constant</b></p>	<b>4</b>

Question Number	Acceptable Answers	Reject	Mark
22 (a) QWC	<p><b>Each mark is a stand alone mark.</b></p> <p><b>First mark:</b></p> <p>hydrogen bonds in <b>both</b> ethanoic acid and ethanol OR no hydrogen bonds in ethanal (1)</p> <p><b>Second mark:</b></p> <p>hydrogen bonds are stronger than van der Waals' / dipole-dipole/London/dispersion/ induced dipole / permanent dipole /intermolecular forces (in ethanal) OR hydrogen bonds are the strongest/strong intermolecular forces (1)</p> <p><b>Third mark:</b></p> <p>ethanoic acid has more electrons/ethanoic acid has the most electrons OR ethanoic acid is dimeric OR ethanoic acid forms dimers OR description of ethanoic acid dimers (N.B. In the context of dimerisation, ignore statement that "ethanoic acid forms two hydrogen bonds per molecule") OR ethanoic acid is more polar because of having more oxygen atoms (1)</p>	<p>any reference to hydrogen bonding in ethanal</p> <p><b>just</b> references to ethanol and ethanoic acid forming H bonds <b>with water</b></p> <p>references to breaking <b>covalent</b> bonds</p> <p><b>Just</b> "ethanoic acid has more hydrogen bonds than ethanol"</p>	3

Question Number	Acceptable Answers	Reject	Mark
22 (b)(i)	<p><b>(Test):</b> 2,4-dinitrophenylhydrazine /Brady's reagent/2,4-dnp/ 2,4-DNP/2,4-DNPH (1)</p> <p><b>(Result):</b>yellow precipitate /orange precipitate /red precipitate</p> <p>ALLOW: 'solid' or 'crystals' in lieu of precipitate (1)</p> <p><b>Result mark for result CQ on correct reagent (or a near miss reagent (e.g. 2,4-DHPN))</b></p>	<p>1,2-DNP etc/ hydrazine / /2,4-dinitrophenolhydrazine /2,4-dinitrophenylhydrazone</p>	2

Question Number	Acceptable Answers	Reject	Mark
22 (b)(ii)	<p>(Warm with) Fehling's (solution) / Benedict's (solution) (1)</p> <p>red precipitate/brown precipitate/brick-red precipitate (1)</p> <p>ALLOW "solid" ALLOW "red Cu<sub>2</sub>O" ALLOW yellow/orange solid for Benedict's test</p> <p><i>Penalise omission of "solid" once only in parts (b)(i) and (b)(ii)</i></p> <p><b>OR</b></p> <p>(Warm with) Tollens' (reagent) (1)</p> <p>silver (mirror)/black(solid) (1)</p> <p><b>(N.B. here, solid not required)</b></p> <p><b>OR</b></p> <p>(Warm with) ammoniacal silver nitrate (solution) (1)</p> <p>silver (mirror)/ black / dark-grey (solid) (1)</p> <p><b>(N.B. here, solid not required)</b></p> <p>2nd mark CQ on correct reagent or a near miss</p> <p><i>Penalise omission of "solid" once only in (b)(i) and (b)(ii)</i></p>	<p>acidified potassium dichromate(VI) / manganate(VII) (0)</p> <p>iodoform reaction (0)</p> <p>just "red due to Cu<sup>+</sup>" / "red solid due to Cu<sup>3+</sup>" (0)</p>	2

Question Number	Acceptable Answers	Reject	Mark
22 (c)(i)	<p>(1) both arrows (1)</p> <p>(1)</p> <p><i>IGNORE</i> any dipoles shown</p> <p>Check curly arrows are all <b>double-headed</b> in mechanism. (If all arrows are <b>single-headed</b>, can only score intermediate mark.)</p> <p><b>Accept:</b> arrow to an <math>H^+</math> instead of an H-CN for third mark. [It is <b>not</b> necessary to show the lone pairs.]</p> <p><i>IGNORE</i> any equations which generate <math>CN^-</math> ions</p>	<p>← N</p> <p>arrow from N in <math>CN^-</math></p>	3

Question Number	Acceptable Answers	Reject	Mark
22 (c)(ii)	<p>With HCN alone, insufficient <math>CN^-</math></p> <p>OR</p> <p>KCN provides (sufficient) <math>CN^-</math></p> <p>OR</p> <p>KCN increases the concentration of <math>CN^-</math></p> <p><i>ALLOW</i> "nucleophile" instead of <math>CN^-</math></p> <p><i>IGNORE</i> any subsequent comments about the role of the <math>CN^-</math> ion</p>	<p>Just "HCN is a weak acid"</p> <p>OR</p> <p>HCN "is too weak a nucleophile"</p>	1



Question Number	Acceptable Answers	Reject	Mark
23 (a)(i)	<p><b>These are stand alone marks</b></p> <p><b>First mark:</b></p> <p>(ensures that) <math>[H^+]</math> and [propanone] (virtually) constant  OR  so that the <math>[H^+]</math> and [propanone] do not affect the rate (1)</p> <p><b>Second mark:</b></p> <p>the <math>[I_2]</math> / iodine concentration changes  OR  so that the <b>overall</b> order (of reaction) is <b>not</b> determined  OR  otherwise a curve (graph) is obtained (1)</p> <p><b>NOTE:-</b></p> <p>“only the <math>[I_2]</math> changes scores (2)  OR  “only the <math>I_2</math> concentration changes” scores (2)  <b>BUT</b>  “only the iodine changes” scores (1)</p>		2

Question Number	Acceptable Answers	Reject	Mark
23 (a)(ii)	<p><b>First mark:</b></p> <p>double the concentration of propanone  OR  change/increase/decrease the concentration of propanone  (1)</p> <p><b>Second mark (mark consequentially):</b></p> <p>slope/gradient of line doubles  ALLOW "rate doubles"  OR  slope or gradient changes/increases/decreases by same factor  ALLOW "rate changes/increases/decreases by same factor"  (1)</p> <p><b>NOTE: may suggest a different procedure:-</b></p> <p><b>First mark:</b></p> <p>monitor/measure [propanone] over time  (1)</p> <p><b>Second mark (mark consequentially):</b></p> <p>plot [propanone] v. time graph and state that <math>t_{1/2}</math> constant  (1)</p>		2



Question Number	Acceptable Answers	Reject	Mark
23 (a)(iii)	<p>I<sub>2</sub> not involved in rate-determining step/  I<sub>2</sub> not involved in slow(est) step /  H<sup>+</sup> and propanone involved in rate-determining step/  H<sup>+</sup> and propanone involved in slow(est)step  (1)</p> <p>so there must be another step where I<sub>2</sub> is involved/  so there must be a fast step where I<sub>2</sub> is involved  (1)</p> <p><b>BUT:-</b></p> <p>I<sub>2</sub> not involved until <b>after</b> the rate-determining step/  I<sub>2</sub> not involved until <b>after</b> the slow(est) step  (2)</p> <p><b>ALLOW</b></p> <p>H<sup>+</sup> involved in rate-determining step  (1)</p> <p>and is regenerated as it is a catalyst (in another step)  (1)</p>	I <sub>2</sub> involved <b>before</b> rate-determining/slowest step (0)	2

Question Number	Acceptable Answers	Reject	Mark
23 (b)(i)	$\text{HCO}_3^- + \text{H}^+ \rightarrow \text{H}_2\text{O} + \text{CO}_2$ OR $\text{HCO}_3^- + \text{H}^+ \rightarrow \text{H}_2\text{CO}_3$ OR $\text{HCO}_3^- + \text{H}_3\text{O}^+ \rightarrow 2\text{H}_2\text{O} + \text{CO}_2$ OR $\text{HCO}_3^- + \text{H}_3\text{O}^+ \rightarrow \text{H}_2\text{CO}_3 + \text{H}_2\text{O}$ <b>ALLOW:</b> $\text{NaHCO}_3 + \text{H}^+ \rightarrow \text{Na}^+ + \text{H}_2\text{O} + \text{CO}_2$ OR $\text{Na}^+ + \text{HCO}_3^- + \text{H}^+ \rightarrow \text{Na}^+ + \text{H}_2\text{O} + \text{CO}_2$ <b>IGNORE</b> any correct or any incorrect state symbols	$\text{NaHCO}_3 + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2$ OR any equations with HA	1

Question Number	Acceptable Answers	Reject	Mark
23 (b)(ii)	$\text{CH}_3\text{COCH}_3 + 3\text{I}_2 + 4\text{NaOH}$ $\rightarrow \text{CHI}_3 + \text{CH}_3\text{COONa} + 3\text{NaI} + 3\text{H}_2\text{O}$ <b>IGNORE</b> any correct or any incorrect state symbols  <b>CHI<sub>3</sub></b> on RHS of equation (1) remaining species correct (1) balanced equation (1)  <b>NOTE:</b> balancing mark is CQ on all species correct  <b>Accept</b> correct ionic equation (i.e. $\text{Na}^+$ omitted)  NOTE: If $\text{CH}_3\text{I}$ , can only access second mark above		3

Question Number	Acceptable Answers	Reject	Mark
24 (a)	$K_p = \frac{p(\text{H}_2)^3 p(\text{CO})}{p(\text{CH}_4)p(\text{H}_2\text{O})}$ <p style="text-align: right;">(1)</p> Brackets not required	$K_p = \frac{p(\text{H}_2)^3 + p(\text{CO})}{p(\text{CH}_4) + p(\text{H}_2\text{O})}$	1

Question Number	Acceptable Answers	Reject	Mark
24 (b)(i)	No effect (as $K_p$ dependent only on temperature) <p style="text-align: right;">(1)</p>		1

Question Number	Acceptable Answers	Reject	Mark
24 (b)(ii)	<p>(Since <math>K_p = \frac{x(\text{H}_2)^3 x(\text{CO})}{x(\text{CH}_4)x(\text{H}_2\text{O})} \times \frac{P_T^{-4}}{P_T^{-2}}</math>)</p> <p>to maintain <math>K_p</math> constant, mole fractions of numerator must decrease OR mole fractions of denominator must increase as <math>\times P_T^{-2}</math> overall)</p> <p><b>First mark:</b></p> <p><i>EITHER</i> mole fractions/partial pressures of numerator decrease <i>OR</i> mole fractions/partial pressures of denominator increase</p> <p style="text-align: right;">(1)</p> <p><b>Second mark:</b></p> <p>any mention of <math>\times P_T^{-2}</math> OR <math>\times \frac{P_T^{-4}}{P_T^{-2}}</math></p> <p style="text-align: right;">(1)</p> <p><i>ALLOW P for <math>P_T</math></i></p> <p><b>NOTE:</b> If Le Chatelier quoted, statements such as: “Equilibrium shifts to side of fewer moles (of gas molecules)/fewer (gas) molecules” max (1)</p>		2

Question Number	Acceptable Answers	Reject	Mark
24 (b)(iii)	<p>Reaction takes place on <b>surface</b> of the catalyst (1)</p> <p>Active sites/(catalyst) surface is saturated with reactant molecules/reactants (at the pressure of the reaction) (1)</p> <p><i>NOTE:</i> an answer such as “... depends on the availability of active sites on catalyst surface” scores (2)</p>		2

Question Number	Acceptable Answers	Reject	Mark																				
24 (c)	$\text{CO} + \text{H}_2\text{O} \rightleftharpoons \text{CO}_2 + \text{H}_2$ <table border="1" style="margin-left: auto; margin-right: auto;"> <tbody> <tr> <td>initial</td> <td>1</td> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>eq'm</td> <td>0.25</td> <td>0.25</td> <td>0.75</td> <td>0.75</td> </tr> <tr> <td>mol frac</td> <td>0.125</td> <td>0.125</td> <td>0.375</td> <td>0.375</td> </tr> <tr> <td>pp</td> <td>3.75</td> <td>3.75</td> <td>11.25</td> <td>11.25</td> </tr> </tbody> </table> <ul style="list-style-type: none"> <li>• eq'm moles all correct (1)</li> <li>• mole fractions all correct (1)</li> <li>• partial pressures and answer = 9 <b>with no units</b> (1)</li> </ul> <p><i>NOTE:</i> 3rd mark not awarded if any units shown</p> <p><i>NOTE:</i></p> $\frac{11.25^2}{3.75^2} = 9$ <p style="text-align: right;">scores (3)</p> <p><i>NOTE:</i> Mark each step CQ. <b>CHECK ALL WORKING</b></p>	initial	1	1	0	0	eq'm	0.25	0.25	0.75	0.75	mol frac	0.125	0.125	0.375	0.375	pp	3.75	3.75	11.25	11.25		3
initial	1	1	0	0																			
eq'm	0.25	0.25	0.75	0.75																			
mol frac	0.125	0.125	0.375	0.375																			
pp	3.75	3.75	11.25	11.25																			

Question Number	Acceptable Answers	Reject	Mark
24 (d)(i)	production (of hydrogen) forms CO <sub>2</sub> OR production (of hydrogen) forms a Greenhouse gas OR production (of hydrogen) forms CO OR CO <sub>2</sub> is a Greenhouse gas OR CO is a Greenhouse gas  ALLOW production (of hydrogen) uses/requires energy  ALLOW CO is toxic/poisonous	methane produced (0)	1

Question Number	Acceptable Answers	Reject	Mark
24 (d)(ii)	$2\text{KHCO}_3 \rightarrow \text{K}_2\text{CO}_3 + \text{CO}_2 + \text{H}_2\text{O}$  ALLOW multiples		1

Question Number	Acceptable Answers	Reject	Mark
24 (e)	products removed OR not a closed system OR balance between rate and yield OR balance between time and yield OR recycling of reactants OR more product in unit time (so process more economically viable)  IGNORE any comments relating to cost	references to atom economy  dangers of maintaining high pressures	1

## Section C

Question Number	Acceptable Answers	Reject	Mark
25 (a)	$\Delta S^{\circ}_{\text{total}}$ is positive / $\Delta S^{\circ}_{\text{total}} > 0$ with or without superscript  <b>NOTE: This mark may be awarded from answer to Q25(b)(v)</b>  <b>Accept</b> $\Delta G^{\circ}$ is negative	<b>Just</b> “the entropy is positive”	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
25 (b)(i)	(+)27.3 and (+)87.4 (J mol <sup>-1</sup> K <sup>-1</sup> )  <i>IGNORE</i> incorrect units		<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
25 (b)(ii)	$\Delta S^{\circ}_{\text{sys}} = (2 \times 87.4) - \{(4 \times 27.3 + (3 \times 205.0))\}$ <p style="text-align: right;">(1)</p> $= -549.4 / -549 \text{ (J mol}^{-1} \text{ K}^{-1}\text{)}$ <p style="text-align: right;">(1)</p> Correct answer with or without correct units (2) <i>IGNORE any wrong units</i>  Accept TE from (b)(i)  <b>NOTE: +549/ +549.4 scores (1)</b>  <b>Check working</b>  <b>NOTE:</b> 1 <sup>st</sup> mark: for x2, x4 and x3 2 <sup>nd</sup> mark: for (products - reactants), with correct arithmetic		<b>2</b>



Question Number	Acceptable Answers	Reject	Mark
25 (b)(v)	<p>(<math>\Delta S_{\text{system}}</math> is negative):</p> <p>as loss of disorder as gas <math>\rightarrow</math> solid</p> <p>OR</p> <p>more order as gas <math>\rightarrow</math> solid</p> <p>OR</p> <p>as decrease in entropy as gas <math>\rightarrow</math> solid</p> <p style="text-align: right;">(1)</p> <p>(<math>\Delta S_{\text{surr}}</math> is positive):</p> <p>(heat) energy released (increases kinetic energy and hence movement of the surrounding molecules)</p> <p style="text-align: right;">(1)</p> <p><math>\Delta S_{\text{total}}</math> is positive because <math>\Delta S_{\text{surr}}</math> is (numerically) greater than <math>\Delta S_{\text{sys}}</math></p> <p>OR</p> <p><math>\Delta S_{\text{surr}}</math> “outweighs” <math>\Delta S_{\text{sys}}</math></p> <p>OR</p> <p><math>\Delta S_{\text{surr}}</math> sufficiently large so that <math>\Delta S_{\text{total}}</math> is positive</p> <p style="text-align: right;">(1)</p>	<p>Just “reaction is exothermic”</p> <p><math>\Delta S_{\text{total}}</math> is negative (0) for third scoring point</p>	3



Question Number	Acceptable Answers	Reject	Mark
26 (a)	<p>(IR spectrum of X)</p> <p>peak at 3400 (cm<sup>-1</sup>) (1)</p> <p><i>MAY BE ANNOTATED ON SPECTRUM</i></p> <p><i>ALLOW</i> anything in the Data Booklet range which is 3200 to 3750 (cm<sup>-1</sup>)</p> <p>X has an O-H (group) OR X is an alcohol (1)</p> <p><b>(From the chemical information)</b></p> <p>X is primary or secondary (alcohol) OR X is not tertiary (alcohol) OR X is any two from:</p> <p>butan-1-ol, butan-2-ol, (2)-methylpropan-1-ol (1)</p> <p>Y is an aldehyde or a ketone <i>ALLOW</i> “ Y is a carbonyl” (1)</p> <p><i>NOTE RE THIRD/FOURTH SCORING POINTS:</i></p> <p>If just state that X is butan-1-ol with no justification (0) but then go on to state Y is butanal, give (1) CQ mark</p> <p>OR</p> <p>If just state that X is butan-2-ol with no justification (0) but then go on to state Y is butanone, give (1) CQ mark</p> <p>OR</p> <p>If just state that X is (2)-methylpropan-1-ol with no justification (0) but then go on to state Y is (2)-methylpropanal, give CQ mark (1)</p> <p><b>NOTE: These Part (a) marks may be awarded from answers to either Part (a) or Part (b)</b></p>	X is a phenol (0)	4

26 (b)  
QWC

First two marks:

X is  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$  (1)

Y is  $\text{CH}_3\text{COCH}_2\text{CH}_3$  (1)

These marks are stand alone

*NOTE:* Two correct names, but no structural formulae for both scores (1) out of (2)

If X identified as  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$   
and

and Y identified as  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$

award (1) unless previously credited in (a)

(NMR spectrum of X)

Third mark:-

hydrogen OR H in five (different) environments

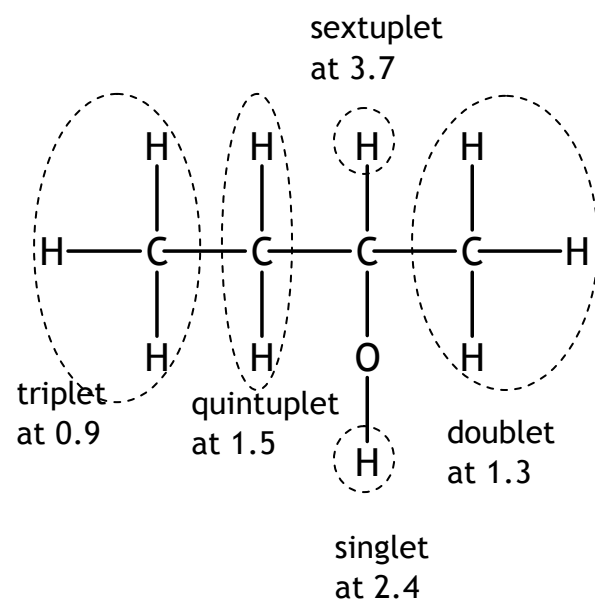
(*IGNORE* reference to butan-1-ol here)

OR

(so must be butan-1-ol or butan-2-ol and) not 2-methylpropan-1-ol which has four peaks/hydrogen environments

(1)

*NOTE:* Candidates may annotate a structural or displayed formula to show that there are five environments. (For this mark, no details of splitting or chemical shifts are needed.)



splitting pattern (2,6,1,5,3) consistent with butan-2-ol

OR

splitting pattern inconsistent with butan-1-ol (which is 3,6,5,3,1)

(1)

6

**Fourth mark:-**  
splitting pattern (2,6,1,5,3) consistent with butan-2-ol

OR

splitting pattern inconsistent with butan-1-ol (which is 3,6,5,3,1)

OR

assign peaks correctly quoting chemical shifts from the spectrum

(1)

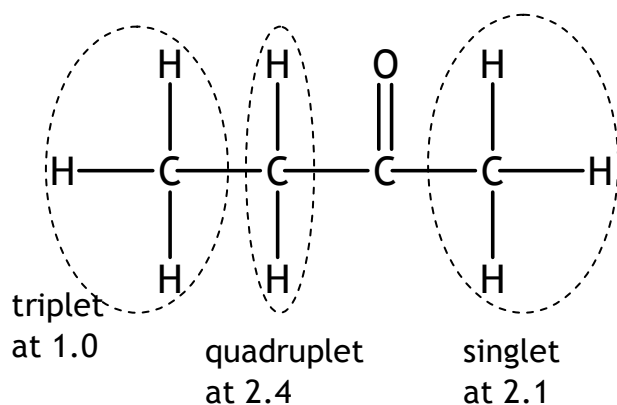
(NMR spectrum of Y)

**Fifth mark:-**

hydrogen OR H in three (different) environments

(1)

*NOTE:* Candidates may annotate a structural or displayed formula to show that there are three environments. (For this mark, no details of splitting or chemical shifts are needed.)



**Sixth mark:-**

splitting pattern (1,4,3) is consistent with butanone

OR

splitting pattern is inconsistent with butanal (which is 3,6,4,3)

OR

splitting pattern inconsistent with 2-methylpropanal (which is 2,8,2)

OR

assign peaks correctly quoting chemical shifts from the spectrum

(1)

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