

Mark Scheme (Results)

January 2013

GCE Chemistry (6CH04) Paper 01

General Principles of Chemistry I 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.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:
 - i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
 - ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
 - iii) organise information clearly and coherently, using specialist vocabulary when appropriate

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	Correct Answer	Mark
1(a)	A	1

Question Number	Correct Answer	Mark
1(b)	C	1

Question Number	Correct Answer	Mark
2	B	1

Question Number	Correct Answer	Mark
3	D	1

Question Number	Correct Answer	Mark
4	D	1

Question Number	Correct Answer	Mark
5	B	1

Question Number	Correct Answer	Mark
6(a)	C	1

Question Number	Correct Answer	Mark
6(b)	B	1

Question Number	Correct Answer	Mark
6(c)	D	1

Question Number	Correct Answer	Mark
7	A	1

Question Number	Correct Answer	Mark
8	C	1

Question Number	Correct Answer	Mark
9	B	1

Question Number	Correct Answer	Mark
10	C	1

Question Number	Correct Answer	Mark
11	D	1

Question Number	Correct Answer	Mark
12(a)	B	1

Question Number	Correct Answer	Mark
12(b)	A	1

Question Number	Correct Answer	Mark
12(c)	C	1

Question Number	Correct Answer	Mark
12(d)	A	1

Question Number	Correct Answer	Mark
13	A	1

Question Number	Correct Answer	Mark
14	A	1

Question Number	Acceptable Answers	Reject	Mark
15(b)(ii)	<p>First mark Gas formed (from solid) OR Liquid formed (from solid) OR Gas and liquid formed (from solid) (1)</p> <p>Second mark EITHER More moles of product than reactants / more moles formed OR 4 mol (of reactants) to 7 mol (of products) OR 4 'molecules' to 7 'molecules' NOTE: If specific numbers are stated, these must be correct (ie 4→7) OR Increase in disorder / increase in ways of arranging particles (1)</p> <p>IGNORE 'entropy increases'</p> <p>NOTE: Both points may be made in the same sentence</p>	<p>Just 'more product' / 'more particles formed'</p> <p>2 substances going to 3 substances</p>	2

Question Number	Acceptable Answers	Reject	Mark
15(b)(iii)	<p>$(\Delta S^{\circ}_{\text{surroundings}} =) \frac{-\Delta H}{T} \text{ OR } \frac{-70000}{298}$ (1)</p> <p>= -234.8993289 = -235 J mol⁻¹ K⁻¹ (1)</p> <p>OR</p> <p>$(\Delta S^{\circ}_{\text{surroundings}} =) \frac{-\Delta H}{T} \text{ OR } \frac{-70}{298}$ (1)</p> <p>= - 0.235 kJ mol⁻¹ K⁻¹ (1)</p> <p>IGNORE sf except 1 sf NOTE: Correct units are required for the award of the second mark +235 with units scores (1)</p>	<p>Incorrect rounding (e.g. -234 / -234.89) no 2nd mark</p> <p>+235 with no units (0) overall</p>	2

Question Number	Acceptable Answers	Reject	Mark
15(b)(iv)	$(\Delta S^{\circ}_{\text{total}} = \Delta S^{\circ}_{\text{system}} + \Delta S^{\circ}_{\text{surroundings}})$ $= (+546) + (-235)$ $= (+)311 \text{ (J mol}^{-1} \text{ K}^{-1}\text{)}$ OR $= (+)0.311 \text{ kJ mol}^{-1} \text{ K}^{-1}$ CQ on (i) and (iii) IGNORE sf except 1 sf	Incorrect units	1

Question Number	Acceptable Answers	Reject	Mark
15(b)(v)	Positive so feasible / spontaneous / will occur / reaction goes / reacts (at 298 K) NOTE: LOOK BACK at answer to (b)(iv) IF answer to (b)(iv) has a positive sign (the + sign can be stated or implied) THEN ALLOW JUST feasible / spontaneous / will occur / reaction goes / reacts (at 298 K) Mark CQ on sign of answer to (iv)		1

(Total 9 marks)

Question Number	Acceptable Answers	Reject	Mark
16(a)(i)	$K_w = [\text{H}^+] \times [\text{OH}^-]$ OR $K_w = [\text{H}_3\text{O}^+] \times [\text{OH}^-]$ State symbols are not required IGNORE any incorrect state symbols	Inclusion of $[\text{H}_2\text{O}]$	1

Question Number	Acceptable Answers	Reject	Mark
16(a)(ii)	<p>FIRST, CHECK THE FINAL ANSWER IF answer pH = 11.875 / 11.88 / 11.9 / 12 award 2 marks</p> <p>IGNORE sf except 1 sf</p> $[\text{H}^+] = \frac{K_w}{[\text{OH}^-]} = \frac{1.00 \times 10^{-14}}{0.00750}$ $= 1.3333 \times 10^{-12}$ $= 1.33 \times 10^{-12} \quad \text{(1)}$ <p>(mol dm⁻³)</p> <p>ALLOW first mark for just</p> $[\text{H}^+] = \frac{K_w}{[\text{OH}^-]}$ <p>pH = $-\log_{10} [\text{H}^+] = 11.875$ = 11.88 / 11.9 (1)</p> <p>OR</p> <p>pOH = $-\log_{10} [\text{OH}^-] = 2.12 \quad \text{(1)}$ pH = $pK_w - \text{pOH}$ pH = 11.88 / 11.9 (1)</p> <p>Second mark only awarded CQ if pH between 8 and 14</p>		2

Question Number	Acceptable Answers	Reject	Mark
16(b)	<p>First mark</p> $\text{Moles NaOH} = \frac{0.00750 \times 20.0}{1000}$ $= 1.50 \times 10^{-4} \text{ (mol)}$ <p style="text-align: right;">(1)</p> <p>(Since HCOOH : NaOH ratio is 1:1)</p> <p>Second mark</p> $[\text{HCOOH(aq)}] = \frac{1.50 \times 10^{-4}}{0.0250}$ <p>OR</p> $= 1.50 \times 10^{-4} \times \frac{1000}{25.0}$ <p style="text-align: right;">(1)</p> <p>(= $6.00 \times 10^{-3} \text{ mol dm}^{-3}$)</p> <p>ALTERNATIVE APPROACH:</p> <p>Use of an expression such as $0.00750 \times 20.0 = 25 \times y$ (1)</p> $y = \frac{0.00750 \times 20.0}{25}$ <p style="text-align: right;">(1)</p>		2

Question Number	Acceptable Answers	Reject	Mark
16(c)(i)	<p>(Weak) dissociates / ionizes to a small extent</p> <p>OR dissociate / ionizes partially</p> <p>OR dissociates / ionizes incompletely</p> <p>OR does not fully dissociate / ionize</p> <p>OR forms an equilibrium when reacted with water (1)</p> <p>(Acid) proton donor ALLOW 'proton donator'</p> <p>OR produces / releases H^+ ions</p> <p>OR produces / releases H_3O^+ ions (1)</p> <p>Ignore reference to typical acid reactions</p>	'not easily dissociated'	2

Question Number	Acceptable Answers	Reject	Mark
16(c)(ii)	$(K_a =) \frac{[\text{HCOO}^-][\text{H}^+]}{[\text{HCOOH}]}$ <p>State symbols are NOT required IGNORE any incorrect state symbols</p>	$(K_a =) \frac{[\text{H}^+]^2}{[\text{HCOOH}]}$ <p>Inclusion of $[\text{H}_2\text{O}]$</p>	1

Question Number	Acceptable Answers	Reject	Mark
16(c)(iii)	<p>IGNORE sf except 1 sf THROUGHOUT FIRST, CHECK THE FINAL ANSWER IF answer $K_a = 1.59 \times 10^{-4} \text{ (mol dm}^{-3}\text{)}$ award the first two 2 marks</p> $[\text{H}^+] (= 10^{-\text{pH}} = 10^{-3.01})$ $= 9.77 \times 10^{-4} \text{ (mol dm}^{-3}\text{)}$ <p style="text-align: right;">(1)</p> $K_a = \frac{[\text{H}^+]^2}{[\text{HCOOH}]}$ $K_a = \frac{(9.77 \times 10^{-4})^2}{6.00 \times 10^{-3}}$ $= 1.59 \times 10^{-4} \text{ (mol dm}^{-3}\text{)}$ <p style="text-align: right;">(1)</p> <p>Assumption 1 $[\text{H}^+] = [\text{HCOO}^-]$ OR no H^+ from the (ionization of) water OR H^+ only from the acid</p> <p style="text-align: right;">(1)</p> <p>Assumption 2 Ionization of the (weak) acid is negligible / very small / insignificant OR $[\text{HCOOH}]_{\text{initial}} - x = [\text{HCOOH}]_{\text{eqm}}$ OR $[\text{HCOOH}]_{\text{eqm}} = [\text{HCOOH}]_{\text{initial}}$ OR $[\text{HCOOH}]_{\text{eqm}} = 6.00 \times 10^{-3} \text{ (mol dm}^{-3}\text{)}$ OR $[\text{H}^+] \ll [\text{HA}]$</p> <p style="text-align: right;">(1)</p> <p>Assumptions can be in either order</p>	<p>If incorrect units max 1</p> <p>Just 'partial' / 'incomplete' Or 'no dissociation'</p>	4

<p>16(c)(iii) cont'd</p>	<p>OR</p> $[\text{H}^+] (= 10^{-\text{pH}} = 10^{-3.01})$ $= 9.77 \times 10^{-4} \text{ (mol dm}^{-3}\text{)} \quad \mathbf{(1)}$ $K_a = \frac{[\text{H}^+]^2}{[\text{HCOOH}]}$ $K_a = \frac{(9.77 \times 10^{-4})^2}{(6.00 \times 10^{-3} - 9.77 \times 10^{-4})}$ $= 1.90 \times 10^{-4} \text{ (mol dm}^{-3}\text{)} \quad \mathbf{(1)}$ <p>Assumption $[\text{H}^+] = [\text{HCOO}^-]$ OR no $[\text{H}^+]$ from the (ionization of) water OR H^+ only from the acid $\mathbf{(1)}$</p> <p>Ignore references to constant temperature</p>		
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(Total 12 marks)

Question Number	Acceptable Answers	Reject	Mark
17(a)(i)	$(K_c =) \frac{[\text{CH}_3\text{COOCH}_2\text{CH}_3] [\text{H}_2\text{O}]}{[\text{CH}_3\text{COOH}] [\text{CH}_3\text{CH}_2\text{OH}]}$ ALLOW C ₂ H ₅ for CH ₃ CH ₂ State symbols are not required IGNORE any incorrect state symbols		1

Question Number	Acceptable Answers	Reject	Mark										
17(a)(ii)	<table border="1"> <thead> <tr> <th>Component</th> <th>CH₃COOH(l)</th> <th>CH₃CH₂OH(l)</th> <th>CH₃COOCH₂CH₃(l)</th> <th>H₂O(l)</th> </tr> </thead> <tbody> <tr> <td>Equilibrium amount / mol</td> <td>(0.20)</td> <td>0.10</td> <td>0.20</td> <td>0.35</td> </tr> </tbody> </table> <p style="text-align: center;">BOTH 0.10 AND 0.20 (1) 0.35 (1)</p> 0.10 and 0.20 scores first mark Allow 0.1 and 0.2 0.35 scores second mark	Component	CH ₃ COOH(l)	CH ₃ CH ₂ OH(l)	CH ₃ COOCH ₂ CH ₃ (l)	H ₂ O(l)	Equilibrium amount / mol	(0.20)	0.10	0.20	0.35		2
Component	CH ₃ COOH(l)	CH ₃ CH ₂ OH(l)	CH ₃ COOCH ₂ CH ₃ (l)	H ₂ O(l)									
Equilibrium amount / mol	(0.20)	0.10	0.20	0.35									

Question Number	Acceptable Answers	Reject	Mark
17(a)(iii)	Units cancel OR same number of moles /same number of molecules on each side OR volume / V cancels Ignore statements such as 'concentrations cancel' 'products and reactants cancel' 'same number of products as reactants'	Concentrations are the same	1

Question Number	Acceptable Answers	Reject	Mark
17(a)(iv)	$K_c = \frac{(0.20) / V \times (0.35) / V}{(0.20) / V \times (0.10) / V}$ $= 3.5 / 3.50$ Correct answer with or without working scores 1 Ignore omission of V TE from values in (ii) table	$K_c = 4$	1

Question Number	Acceptable Answers	Reject	Mark
17(b)	<ul style="list-style-type: none"> No effect on (position of) equilibrium (1) Rate (of attainment of equilibrium) is faster / equilibrium reached sooner (1) 		2

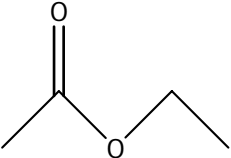
Question Number	Acceptable Answers	Reject	Mark
17(c)(i)	<p>Bonds Broken C—O and O—H (1) Ignore where these bonds are broken in the acid and alcohol molecules.</p> <p>ALLOW C—OH for C—O CO—H for O—H</p> <p>Bonds Made C—O and O—H (1) Ignore where these bonds are made in the ester and water molecules.</p> <p>ALLOW C—OC for C—O H—OH for O—H</p> <p>Marks can be awarded by annotating displayed or structural formulae.</p> <p>Comment: Max 1 if any other bonds mentioned</p>	<p>Two O—H bonds formed in H₂O molecule</p> <p>ONLY C—O bond broken and made scores (0) overall</p>	2

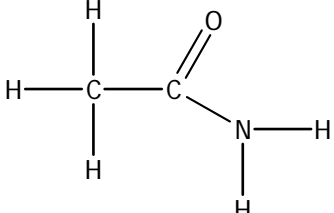
Question Number	Acceptable Answers	Reject	Mark
17(c)(ii)	<p>(C—O and O—H) bond enthalpies differ in: different environments /different molecules /different compounds OR Bond enthalpies/bond energies are average values</p> <p>ALLOW Bonds being broken and made are attached to different atoms</p>	'Heat loss'	1

Question Number	Acceptable Answers	Reject	Mark
17(d)(i)	<p>$\Delta S_{\text{total}} = R \ln K$</p> <p>Allow ΔS_{total} is proportional to <u>ln</u>K</p> <p>ALLOW K_c or K_p instead of K</p>	<p>log instead of ln</p> <p>ΔS_{total} is proportional to K / ΔS_{total} increases as K increases</p>	1

Question Number	Acceptable Answers	Reject	Mark
*17(d)(ii)	<p>First mark:</p> <p>$(\Delta H = 0 \text{ so})$</p> <p>$\Delta S_{\text{surroundings}} = 0$</p> <p>OR</p> <p>$-\frac{\Delta H}{T} = 0$</p> <p style="text-align: right;">(1)</p> <p>IGNORE "$\Delta S_{\text{surroundings}}$ stays the same".</p> <p>Second mark:</p> <p>(so) ΔS_{total} does not change</p> <p>OR</p> <p>(so) $\Delta S_{\text{total}} = \Delta S_{\text{system}}$</p> <p style="text-align: right;">(1)</p> <p>Third mark:</p> <p>(As $\Delta S_{\text{total}} = R \ln K$) K does not alter</p> <p style="text-align: right;">(1)</p> <p>ALLOW "it does not alter" to assume K does not alter.</p> <p>ALLOW use of K_c or K_p instead of K</p> <p>Each point is stand alone</p> <p>IGNORE justifications in terms of Le Chatelier's Principle</p> <p>NOTE:</p> <p>Can award max (1) (i.e. the third scoring point) if the effect on K stated follows on CQ from a change to ΔS_{total}</p>	<p>If only mentions 'no effect on position of equilibrium' rather than the equilibrium constant</p>	3

Question Number	Acceptable Answers	Reject	Mark
17(e)(i)	$\text{CH}_3\text{COCl} + \text{CH}_3\text{CH}_2\text{OH} \rightarrow$ $\text{CH}_3\text{COOCH}_2\text{CH}_3 + \text{HCl}$ Allow C_2H_5 for CH_3CH_2 Allow $\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_3$ for $\text{CH}_3\text{COOCH}_2\text{CH}_3$ IGNORE missing or incorrect state symbols	$\text{CH}_3\text{CClO} / \text{CH}_2\text{CH}_3\text{OH}$	1

Question Number	Acceptable Answers	Reject	Mark
17(e)(ii)	 IGNORE Bond angles and length of the lines.		1

Question Number	Acceptable Answers	Reject	Mark
17(e)(iii)	 IGNORE Other products of the reaction if the above structure has been correctly drawn.	NH_2 or CH_3	1

Question Number	Acceptable Answers	Reject	Mark
17(f)(i)	$(\text{CH}_3\text{COOCH}_2\text{CH}_3 + \text{NaOH} \rightarrow)$ $\text{CH}_3\text{COONa} + \text{CH}_3\text{CH}_2\text{OH} / \text{C}_2\text{H}_5\text{OH}$ Allow ionic representations of the sodium salt $\text{CH}_3\text{COO}^-\text{Na}^+$ IGNORE missing or incorrect state symbols	$\text{CH}_2\text{CH}_3\text{OH}$ for ethanol	1

Question Number	Acceptable Answers	Reject	Mark
17(f)(ii)	(Reaction with sodium hydroxide is) not an equilibrium / not reversible / goes to completion OR Reverse argument for acid hydrolysis		1

(Total 19 marks)

Question Number	Acceptable Answers	Reject	Mark
18(a)(i)	<ul style="list-style-type: none"> • In experiments 1 and 2, $[H^+]$ doubles (whilst keeping other concentrations constant) and the rate quadruples / rate increases x 4 (1) • Second order (with respect to H^+) (1) • In experiments 1 and 3, $[Br^-]$ doubles and $[BrO_3^-]$ triples (with $[H^+]$ constant) (1) • Rate increases by 3×2 / rate increases x 6 / rate increases to 5.04×10^{-5} (then to 1.01×10^{-4} stated or implied) (1) • First order with respect to Br^- (1) <p>OR</p> <ul style="list-style-type: none"> • In experiments 2 and 3, $[Br^-]$ doubles and $[BrO_3^-]$ triples and $[H^+]$ halves (1) • Rate increases by $3 \times 0.25 \times 2$ / rate increases x 1.5 (1) • First order with respect to Br^- (1) <p>Penalise OMISSION of Experiment Numbers once only</p> <p>Mark each point independently</p>		5

Question Number	Acceptable Answers	Reject	Mark
18(a)(ii)	<p>Rate = $k [BrO_3^-] [Br^-] [H^+]^2$</p> <p>Mark CQ on (a)(i) Allow "r" or "R" for "rate" in the rate equation. IGNORE If k appears to be in upper case.</p>		1

Question Number	Acceptable Answers	Reject	Mark
18(a)(iii)	<p>IGNORE sf except 1 sf THROUGHOUT</p> <p>FIRST, CHECK THE FINAL ANSWER</p> <p>IF answer $k = 1.49 \times 10^{-2} \text{ dm}^9 \text{ mol}^{-3} \text{ s}^{-1}$ award (3) marks</p> $k = \frac{\text{rate}}{[\text{BrO}_3^-] [\text{Br}^-] [\text{H}^+]^2}$ $= \frac{1.68 \times 10^{-5}}{0.05 \times 0.25 \times (0.30)^2} \quad \text{(1)}$ $= 0.014933333 \quad \text{(1)}$ $= 0.0149 \quad \text{(1)}$ $\text{dm}^9 \text{ mol}^{-3} \text{ s}^{-1} / \text{mol}^{-3} \text{ dm}^9 \text{ s}^{-1} \quad \text{(1)}$ <p>IGNORE sf except 1 sf Mark CQ from (a)(ii) or, if no rate equation in (a)(ii), then any rate equation stated in (a)(iii)</p> <p>NOTE: IF the rate equation in (a)(ii) is given as Rate = $k [\text{BrO}_3^-] [\text{H}^+]^2$ CQ $k = 3.73 \times 10^{-3} \text{ dm}^6 \text{ mol}^{-2} \text{ s}^{-1}$ scores (3)</p> <p>IF $[\text{H}^+]$ is not squared in the correct rate equation: $k = 4.48 \times 10^{-3} \text{ dm}^9 \text{ mol}^{-3} \text{ s}^{-1}$ OR $k = 4.48 \times 10^{-3} \text{ dm}^6 \text{ mol}^{-2} \text{ s}^{-1}$ scores (2)</p> <p>ALLOW Correct answers derived from the data in the table for Experiment 2 or Experiment 3</p>		3

Question Number	Acceptable Answers	Reject	Mark
18(b)	<p>The number(s) (of particles) in the rate equation / rate-determining step do not match those in the equation for the reaction</p> <p>OR</p> <p>The chance of (simultaneous) collision of 12 particles is unlikely</p> <p>OR</p> <p>The chance of (simultaneous) collision of 4 particles is unlikely</p> <p>OR</p> <p>The chance of (simultaneous) collision of 3 reactants is unlikely</p> <p>ALLOW</p> <p>'molecules' / 'substances' for 'particles'</p> <p><u>NOTE</u></p> <p>ALLOW AS A CQ from (a)(ii) Br^- ions not in rate equation / Br^- ions not in rate-determining step / Zero order with respect to Br^- / (Only) two reactants in the rate-determining step / (only) two reactants in the rate-equation/ particles are in the equation (for the reaction) that are not in the rate equation</p>		1

Question Number	Acceptable Answers	Reject	Mark
18(c)	<p>REMEMBER TO SCROLL DOWN BELOW THE SPACE LEFT FOR A SKETCH-GRAPH TO SEE WHAT CANDIDATE HAS WRITTEN ON THE DOTTED LINES</p> <ul style="list-style-type: none"> • (Calculate) gradient (of tangent) (1) ALLOW 'slope' for 'gradient' • At $t = 0$ / at the start / at the beginning / when reaction is at its fastest / at the origin (1) <p>Each mark is stand-alone</p> <p>NOTE: Answer may be annotated on a suitable sketch-graph</p> <p>IGNORE any sketch-graph that shows an increase in concentration with time</p> <p>MAX (1) if sketch-graph shows a decrease in the concentration of a reactant / Br_2</p>	<p>Answers relating to half-life score (0) overall</p> <p>If sketch-graph or comments suggest that gradient is measured at other than $t = 0$ or at several values of t then max (1)</p>	2

(Total 12 marks)

SECTION C

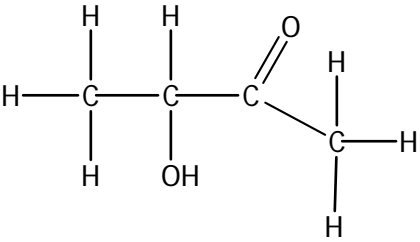
Question Number	Acceptable Answers	Reject	Mark
19(a)(i)	$\begin{array}{rcc} & \text{C} & : & \text{H} & : & \text{O} \\ \text{Mole ratio / mol} & \underline{54.5} & : & \underline{9.1} & : & \underline{36.4} \\ & 12 & & 1 & & 16 \\ & & & & & \mathbf{(1)} \end{array}$ $\begin{array}{rcc} = & 4.5417 & : & 9.1 & : & 2.275 \\ = & 1.996 & : & 4 & : & 1 \\ = & 2 & : & 4 & : & 1 \\ & & & \text{C}_2\text{H}_4\text{O} & & \mathbf{(1)} \end{array}$ <p>Correct empirical formula of C₂H₄O, with or without working, scores (2)</p>		2

Question Number	Acceptable Answers	Reject	Mark
19(a)(ii)	<p>First mark:</p> <p>Any mention of 44 or of doubling C₂H₄O (1)</p> <p>Second mark:</p> <p>Any mention of 88 in the context of the mass spectrum eg mentions 'molecular ion' / M⁺ / heaviest peak / peak furthest to the right / annotation at 88 on the mass spectrum itself / highest $\frac{m}{z}$ value (1)</p>	<p>88 obtained just by adding up the relative atomic masses in C₄H₈O₂ scores (0) for 2nd scoring point</p>	2

Question Number	Acceptable Answers	Reject	Mark
19(b)	<p>(Peak at 3500 cm⁻¹) O—H (1) Allow OH</p> <p>(Peak at 1700 cm⁻¹) C=O (1)</p> <p>Penalise extra extension bond on an otherwise correct answer once only (eg —O—H and —C=O scores (1))</p> <p>IGNORE any names for the bonds suggested even if incorrect</p>	<p>—O—H / —OH</p> <p>C—O / —C=O / CO</p>	2

Question Number	Acceptable Answers	Reject	Mark
19(c)(i)	<p>First mark: (X is neutral) so not a (carboxylic) acid (1)</p> <p>IGNORE "X doesn't have a charge as it is neutral" / "X is not an alkali" / "X is not a base"</p> <p>Second mark: (X does not react with Tollens') so is not an aldehyde / is a ketone (1)</p> <p>Third mark: (X reacts with H^+ / $Cr_2O_7^{2-}$ so) is an alcohol / contains an OH (group) / contains R—OH / contains hydroxyl (group) (1)</p> <p>IGNORE 'not an acid' if this is deduced solely from the H^+ / $Cr_2O_7^{2-}$ information</p> <p>Fourth mark: a primary or a secondary (alcohol) both needed OR (X is) not tertiary (alcohol) (1)</p> <p>Mark each point separately</p> <p>NOTE: 'X is a primary or a secondary alcohol' scores both the third and fourth marks</p> <p>ALLOW Correct formulae for the functional groups, instead of their names</p>	<p>X is an aldehyde scores (0) for this scoring point / X is not a ketone scores (0) for this scoring point</p>	4

Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	(primary or secondary) alcohol and ketone NOTE BOTH names are required here	Just 'hydroxyl for 'alcohol' and/or 'C=O /carbonyl' for ketone/	1

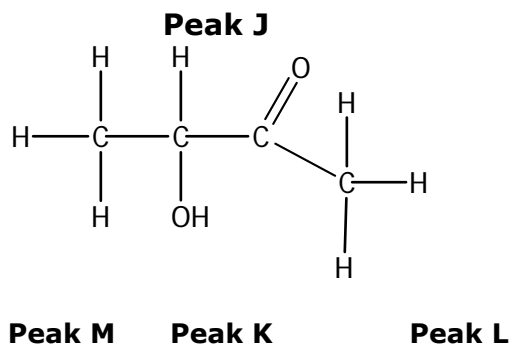
Question Number	Acceptable Answers	Reject	Mark
19(d)	<p>MARKING ADVICE Check answer for the suggested structure of X. If the correct structure is shown</p>  <p>Mark answer according to the following. However if no structure for X is shown or an incorrect structure for X is proposed, mark answer according to "COMMENTS" scheme below</p> <p>MARKS CAN BE AWARDED FROM SUITABLY ANNOTATED FORMULAE FOR X.</p> <p>First mark:</p> <p>Four different H / hydrogen / proton environments (1)</p> <p>Any five from following seven points:</p> <p>Either Application of the (n+1) rule to peak J (which is a quartet / splits into four) or application of the (n+1) rule peak M (which is a doublet / splits into two) (1)</p> <p>Any mention to explain no splitting for peak L as there is no H is attached to the adjacent carbon (1)</p> <p>Peak L (CH₃) next to C=O (1)</p> <p>Peak M (CH₃) next to CH (1)</p> <p>Peak K OH (1)</p> <p>Peak J (CH) next to CH₃ (1)</p> <p>Any one correct δ value quoted within ± 0.2 of the following chemical shifts: 1.4(M) or 2.2 (L) or 3.7(K) or 4.2 (J) (ppm) (1)</p>	<p>Just 'four different chemical environments'</p> <p>If any incorrect chemical shift OR A RANGE of chemical shifts is quoted, this scoring point is not available</p>	7

Final mark

(Compound **X** is) $\text{CH}_3\text{CH}(\text{OH})\text{COCH}_3$
NO other compound allowed.

ACCEPT

any unambiguous formula, e.g. displayed formula

**ACCEPT**

3-hydroxybutan-2-one

(1)

(Total 18 marks)
Total marks 90

COMMENT

Strategy for marking answers with an incorrect structure for X or where no structure is suggested for X.

The maximum mark in such cases is FOUR OUT OF SEVEN or TWO OUT OF SEVEN IF NO STRUCTURE DRAWN (as second and fourth marks are not available)

Scoring points:

First mark:

States four different H / hydrogen / proton environments

Second mark:

Structure drawn for **X** has exactly 4 hydrogen environments

Third mark:

Peak **K** is due to OH

Fourth Mark:

Providing the structure drawn for X would produce ONE of these splits.

Any ONE of

Application of the (n+1) rule to peak to explain a peak which is a quartet splits into **four**
or

Application of the (n+1) rule to peak to explain a peak which is a doublet / splits into **two**
or

Application of the (n+1) rule to peak to explain a peak which is a singlet due to a CH₃ next to C=O

SEE NEXT PAGE FOR MAXIMUM MARKS AVAILABLE FOR SOME LIKELY INCORRECT STRUCTURES FOR **X**

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