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Mark Scheme (Results)

January 2016

Pearson Edexcel International Advanced Level in Chemistry (WCH04) Paper 01 – General Principles of Chemistry I

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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	Reject	Mark
1	D		1

Question Number	Correct Answer	Reject	Mark
2	D		1

Question Number	Correct Answer	Reject	Mark
3	A		1

Question Number	Correct Answer	Reject	Mark
4	C		1

Question Number	Correct Answer	Reject	Mark
5a	C		1

Question Number	Correct Answer	Reject	Mark
5b	B		1

Question Number	Correct Answer	Reject	Mark
5c	C		1

Question Number	Correct Answer	Reject	Mark
6	A		1

Question Number	Correct Answer	Reject	Mark
7	D		1

Question Number	Correct Answer	Reject	Mark
8	B		1

Question Number	Correct Answer	Reject	Mark
9a	A		1

Question Number	Correct Answer	Reject	Mark
9b	B		1

Question Number	Correct Answer	Reject	Mark
10	B		1

Question Number	Correct Answer	Reject	Mark
11	B		1

Question Number	Correct Answer	Reject	Mark
12	D		1

Question Number	Correct Answer	Reject	Mark
13a	C		1

Question Number	Correct Answer	Reject	Mark
13b	C		1

Question Number	Correct Answer	Reject	Mark
13c	D		1

Question Number	Correct Answer	Reject	Mark
14	D		1

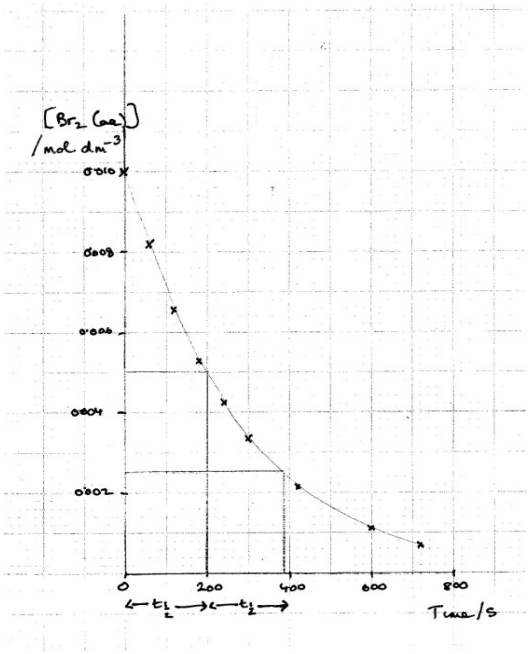
Question Number	Correct Answer	Reject	Mark
15	A		1

TOTAL FOR SECTION A = 20 Marks

Section B

Question Number	Acceptable Answers	Reject	Mark
16a	TWO of Bromine / Br_2 by colorimetry **(1)** Carbon dioxide / CO_2 by (measurement of) gas **volume** / **mass** change **(1)** ALLOW Hydrogen ions / H^+ and / or bromide ions / Br^- By electrical conductivity **(1)** ALLOW Hydrogen ions / H^+ by pH measurement **(1)**	Dilatometry Sampling methods Br / Br^- Calorimetry Just 'gas syringe' 'measure amount of gas' 'use balance' Br_2 or bromine HCOOH	2

Question Number	Acceptable Answers	Reject	Mark
16b(i)	 Suitable scale so the points cover more than half of grid in both directions **and** axes labelled Horizontal axis labelled time /s ALLOW (s) Vertical axis labelled $[Br_2]$ / mol dm^{-3} ALLOW mol / dm^3 $[Br_2] \times 10^{-3}$ /mol dm^{-3} **(1)** Correct plotting of **all** points with smooth curve through all points ALLOW Minor wobbles **(1)**	Non uniform scale scores 0 Br_2 for $[Br_2]$ Straight lines between points	2

Question Number	Acceptable Answers	Reject	Mark
16b(ii)	 Any two half lives **shown on graph** **IGNORE** Third half life even if not 195 ± 15 s **(1)** Each half life 195 ± 15 s must approximately match values from graph This may be shown on the graph **(1)** Third mark is stand alone: Half life is (approximately) constant (so first order) **(1)** ALLOW Lines showing tangents at two different concentrations **(1)** Values of gradients of both tangents **(1)** Gradient (rate) is directly proportional to concentration **(1)**	200 and 400	3

Question Number	Acceptable Answers	Reject	Mark
16b(iii)	**Concentration** of methanoic acid does not change (significantly) during course of reaction (as it is so much greater than concentration of bromine)	Methanoic acid is not involved in the rds Just 'it is in excess'	1

Question Number	Acceptable Answers	Reject	Mark
16b(iv)	Rate/ r/ R = $k[Br_2]^{(1)}[HCOOH]^{(1)}$ Formulae must be correct ALLOW Upper case K for k	Omission of Rate/ r/ R Br / CHOOH /HCOH Lack of square brackets	1

Question Number	Acceptable Answers	Reject	Mark
16b(v)	$k = \frac{4.54 \times 10^{-5}}{0.01 \times 0.5}$ $= 9.08 \times 10^{-3}$ / 0.00908 **(1)** Mark units independently but must match rate equation in 16(b)(iv) $dm^3\,mol^{-1}\,s^{-1}$ (in any order) **(1)** TE on rate equation IGNORE SF NOTE If first order then units are s^{-1}		2

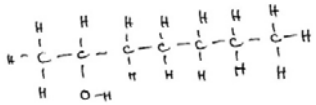
(Total for Question 16 = 11 marks)

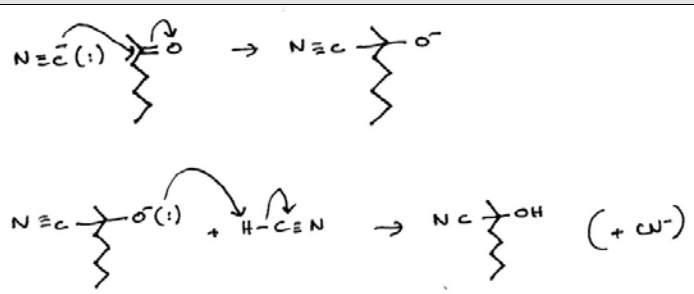
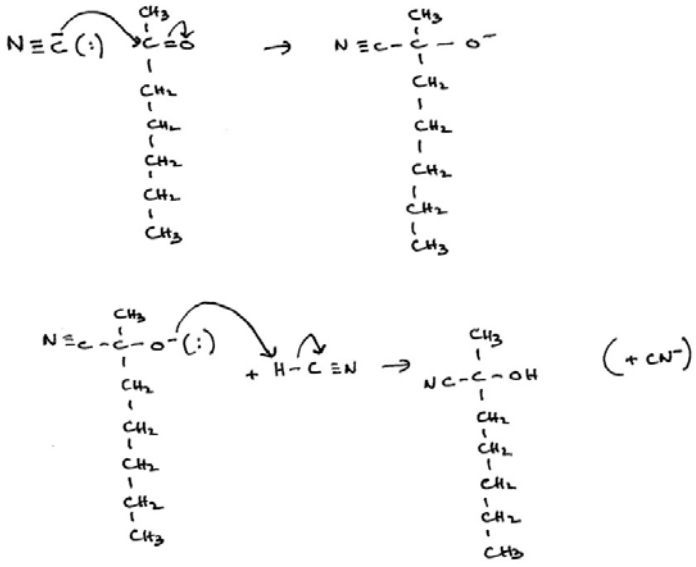
Question Number	Acceptable Answers	Reject	Mark
17a	Heptan-2-one ALLOW Hept-2-one Hepta-2-one Heptane-2-one 2-heptanone	Heptanone	1

Question Number	Acceptable Answers	Reject	Mark
17b	(Warm with) iodine and sodium hydroxide/ iodine in the presence of alkali **(1)** EITHER Yellow **and** precipitate with **A only** OR Yellow **and** precipitate with **A**, no change with **B** ALLOW Antiseptic smell with **A only** ALLOW Correct result following use of just 'iodoform test' for second mark **(1)**	Just 'iodoform test' Measure the melting point of the hydrazone	2

Question Number	Acceptable Answers	Reject	Mark
17c	Test 2 may be given before test 1 Allow a correct result with a nearly correct test eg no acid in dichromate test scores 0 for test but scores 1 for the result remains orange Test 1: (Warm with) Brady's reagent / (2,4-)dinitrophenylhydrazine / (2,4)DNP(H) **(1)** Yellow/ orange/ red **and** precipitate/ solid/ crystals **and** confirms C=O/ carbonyl/ aldehyde or ketone **(1)** Test 2: Any one from (Warm/boil with) Fehling's solution/ Benedict's solution **(1)** No red-brown/ brown/ orange ppt / stays blue, confirms not an aldehyde ALLOW No reaction confirms not an aldehyde/ so it is a ketone **(1)** OR Test 2: (Warm with) Tollens' reagent/ ammoniacal silver nitrate **(1)** No silver mirror/ grey black or silver ppt confirms not an aldehyde ALLOW No reaction confirms not an aldehyde/ so it is a ketone **(1)** OR (Warm with) potassium/sodium dichromate((VI)) **and** sulfuric acid/ $Cr_2O_7^{2-}$ **and** H^+ ALLOW (Warm with) acidified (potassium/ sodium) dichromate((VI)) **(1)** remains orange / does not go green confirms not an aldehyde ALLOW No reaction confirms not an aldehyde/ so it is a ketone **(1)**		4

	Additional Comments READ (b) and (c) TOGETHER DNPH test in (b) scores 0 but if DNPH test is given correctly in (b) allow up to 2 marks for this test in in (c)		

Question Number	Acceptable Answers	Reject	Mark
17d	 OR $CH_3CH(OH)(CH_2)_4CH_3$ / $CH_3CH(OH)CH_2CH_2CH_2CH_2CH_3$ **(1)** Lithium tetrahydridoaluminate((III))/ lithium aluminium hydride / $LiAlH_4$ (in dry ether) ALLOW $NaBH_4$ / sodium borohydride H_2 + Ni/Pt/ Pd catalyst **(1)**	Skeletal formula Lack of hydrogens	2

Question Number	Acceptable Answers	Reject	Mark
17e(i)	 ALLOW  Arrow from any part of CN^- (including a lone pair on either the carbon or nitrogen)to **carbon** of C=O **and** Arrow from part of C=O double bond to oxygen ALLOW CN^- can approach from LHS or RHS of A Two steps via charged canonical form **(1)** Negatively charged intermediate with C-CN bond **(1)** Arrow from resulting O^- to hydrogen of HCN/ H^+/ H_2O Do not penalise incorrect or absent arrow between H and CN **(1)** IGNORE Dipoles on C=O	CN without negative charge C-N-C Penalise once only	3

Question Number	Acceptable Answers	Reject	Mark
17e(ii)	Forms a racemic mixture / racemate **(1)** Cyanide can attack (equally) from either side/ above or below **(1)** Because bonds round C=O are (trigonal) planar / \ C=O is planar / OR Carbonyl group / C=O **group** / reaction site is planar OR Bonds around carbonyl carbon are planar **(1)**	Ketone/ the molecule is planar C=O is planar carbocation / intermediate is planar	3

(Total for Question 17 = 15 marks)

Question Number	Acceptable Answers	Reject	Mark
18a	$K_p = \frac{p(CH_3OH)}{p(CO) \times p(H_2)^2}$ ALLOW Lower or upper case p/ pp Expression without brackets p^2H_2 P_{CO} etc	Square brackets Expressions without p/ pp/ P/PP to show partial pressure	1

Question Number	Acceptable Answers	Reject	Mark
18b			1

	CO	H_2	CH_3OH	total
Mol at start	39.5	77.5	0	
Mol at eqm	**1.0**	**0.5**	38.5	**40(.0)**

Mol H_2 **(1)**
Mol CO **and** total mol
ALLOW
Total mol shown in working below **(1)**

ALLOW
TE on mols of hydrogen

	CO	H_2	CH_3OH
Mole fraction	0.025	0.0125	0.9625
pp	1.25	0.625	48.125

$K_p = ((48.125)/ (1.25) \times (0.625)^2$
$= 98.56 \text{ atm}^{-2}$)
$= 98.6 \text{ atm}^{-2}$

All three partial pressures **(1)**

Correct value for K_p to 3SF
TE on partial pressures and expression for K_p in table **(1)**

Units
TE on expression in table **(1)**

Correct answer with no working scores last 3 marks

If candidate incorrectly use the ratio 1 CO to 1 H_2 then first mark is lost but the remaining four can be achieved as shown below

	CO	H_2	CH_3OH	total
Mol at start	39.5	77.5	0	
Mol at eqm	**1.0**	**39(.0)**	38.5	**78.5**

Mol H_2 **(0)**
Mol CO **and** total mol **(1)**

ALLOW
TE on mols of hydrogen

	CO	H_2	CH_3OH
Mole fraction	0.0127	0.497	0.490
pp	0.637	24.8	24.5

$K_p = ((24.5)/ (0.637) \times (24.8)^2$
$= 0.06259\ atm^{-2}$
$= 0.0626\ atm^{-2}$
If candidate does not approximate to 3 SF during the calculation allow 0.0623 to 0.0625

All three partial pressures **(1)**

Correct value for K_p to 3 SF
TE on partial pressures and expression for K_p in 18(a) **(1)**

Units
TE on expression in 18(a) **(1)**

Correct answer with no working scores last 3 marks

Question Number	Acceptable Answers	Reject	Mark
18c	(K_p is smaller so reaction does not go as far to right) reaction is exothermic/ ΔH is negative **(1)** $\Delta S_{surroundings}$ = -ΔH/T so is positive ALLOW If in explaining $\Delta S_{surroundings}$ is +ve, the expression $\Delta S_{surroundings}$ = — —ΔH/T is quoted, then the mark can be awarded **(1)** IGNORE References to ΔS_{total} = RlnK Endothermic reaction scores 0	Absence of $\Delta S_{surroundings}$ = -ΔH/T	2

Question Number	Acceptable Answers	Reject	Mark
18d	CH_2OH | CHOH | CH_2OH **(1)** + **3** $C_{15}H_{31}COOCH_3$ /$CH_3OOC\ C_{15}H_{31}$ / $CH_3OCOC_{15}H_{31}$ **(1)** ALLOW partially displayed or skeletal formulae		2

(Total for Question 18 = 10 marks)

Question Number	Acceptable Answers	Reject	Mark
19a	Proton/ H^+ donor		1

Question Number	Acceptable Answers	Reject	Mark
19b	pH of HCl = 1 **and** pH of weak acid is greater /higher than 1 Allow any number >1 and <7	 Different (from 1)	1

Question Number	Acceptable Answers	Reject	Mark
19c(i)	HCOOH/ methanoic acid is stronger **because** its K_a is bigger/higher OR its pK_a is smaller / lower (The data: K_a pK_a Methanoic acid 1.6×10^{-4} 3.8 Propanoic acid 1.3×10^{-5} 4.9) IGNORE Discussion of inductive effect		1

Question Number	Acceptable Answers	Reject	Mark
19c(ii)	$(HCOOH + C_2H_5COOH) \rightleftharpoons$ **$HCOO^- + C_2H_5COOH_2^+$** ALLOW TE for equation with propanoic acid as proton donor giving $HCOOH_2^+$ and $C_2H_5COO^-$ if HCOOH is stated to be weaker	$COOH^-$ $C_2H_6COOH^+$	1

Question Number	Acceptable Answers	Reject	Mark
19d	$[H^+] = (1 \times 10^{-14} / [OH^-])$ $= 2 \times 10^{-13}$ (mol dm^{-3}) **(1)** pH = 12.7 **(1)** OR pOH / -log 0.05 = 1.3 **(1)** pH = (14 -1.3 =) 12.7 **(1)** Correct answer with no working scores 2 provided at least 3 SF Allow TE on first mark provided answer >7	 13 13	2

Question Number	Acceptable Answers	Reject	Mark
19e(i)	$C_2H_5COOH + NaOH \rightarrow C_2H_5COO^{(-)} Na^{(+)} + H_2O$ ALLOW $\rightleftharpoons$ for $\rightarrow$ $C_2H_5COO^- + Na^+$ for $C_2H_5COO^{(-)} Na^{(+)}$ IGNORE State symbols even if incorrect		1

Question Number	Acceptable Answers	Reject	Mark
19e(ii)	Allow salt/ C_2H_5COONa/ propanoate ion/ $C_2H_5COO^-$/ base for A^- Allow propanoic acid/ C_2H_5COOH for HA **First mark** $K_a = \frac{[H^+][A^-]}{[HA]}$ OR $\log K_a = \log[H^+] + \log [A^-]/[HA]$ OR $pH = pK_a - \log [HA]/[A^-]$ ALLOW any of these equations re-arranged or used correctly **(1)** **Next four marks** Mol NaOH before mixing = (20 x 0.05/1000) = 0.001 **and** mol propanoic acid before mixing = (20 x 0.25/1000) = 0.005 **(1)** Mol propanoate in mixture = 0.001 OR [propanoate] = (0.001/40 x1000) = 0.025 (mol dm^{-3}) **(1)** Mol propanoic acid in mixture = 0.004 OR [propanoic acid] = (0.004/40 x 1000) = 0.1(mol dm^{-3}) **(1)** $[H^+] = \frac{(1.3 \times 10^{-5})(0.1)}{0.025}$ pH = 4.28/ 4.3 **(1)** Correct pH with no working scores last 4 marks ALLOW Other methods leading to 4.28 e.g. based on equal volumes being mixed so mol propanoate are in double the volume and so concentration is 0.025 mol dm^{-3}		5

Question Number	Acceptable Answers	Reject	Mark
19e(iii)	**First mark** The mixture contains a large amount/ reservoir of a (weak) acid/propanoic acid **and** its conjugate base/ propanoate ions /salt **(1)** **Second mark** Only awarded if at least one equation given Added OH^- combines with H^+ ($H^+ + OH^- \rightarrow H_2O$) from propanoic acid followed by dissociation of more propanoic acid $C_2H_5COOH \rightleftharpoons C_2H_5COO^- + H^+$ OR Added OH^- combines with propanoic acid $OH^- + C_2H_5COOH \rightarrow C_2H_5COO^- + H_2O$ **(1)** **Third mark** (pH is unchanged because added OH^- is removed) change in concentration of $C_2H_5COO^-$ **and** C_2H_5COOH is small / ratio [salt]/[acid] hardly changes **(1)**		3

(Total for Question 19 = 15 marks)

Section C

Question Number	Acceptable Answers	Reject	Mark
20a(i)	ΔS_{system} = 240.0 - 102.5 - 210.7 = -73.2 J mol^{-1} K^{-1}/ -0.0732 kJ mol^{-1} K^{-1} ALLOW -73 J mol^{-1}K^{-1} Correct data **(1)** Final answer with sign and units (in any order) TE on incorrect data **(1)**		2

Question Number	Acceptable Answers	Reject	Mark
20a(ii)	**First check final answer** +118.1 J mol^{-1} K^{-1} / +0.1181 kJ mol^{-1} K^{-1} ALLOW +120 J mol^{-1} K^{-1} **(2)** OR $\Delta S_{surroundings}$ = —(—57 x 1000 /298) = (+)191.3 (J mol^{-1} K^{-1}) ALLOW (+)191 (J mol^{-1}K^{-1}) **(1)** ΔS_{total} = (—73.2 + 191.3) = **+**118.1 J mol^{-1}K^{-1} Use of -73 +191 gives **+**118 **(1)**		2

Question Number	Acceptable Answers	Reject	Mark
20a(iii)	(it ceases when) ΔS_{total} = 0 **(1)** (this is when TΔS_{system} = ΔH) T = $\frac{\Delta H}{\Delta S_{system}} = \frac{57 \times 1000}{73.2}$ = 778.69/ 778.7 / 779 / 780 (K) Use of 73 gives 780.1/ 780 (K) **(1)**	 778 -780.1 -780	2

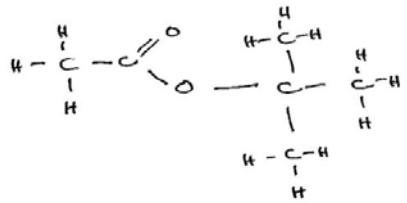
Question Number	Acceptable Answers	Reject	Mark
20b	(Even though thermodynamically feasible) (The reaction is very slow because) the activation energy is high/ there is an activation energy barrier	Reaction is not spontaneous Makes reaction faster Catalyst lowers activation energy Provides an alternative route with a lower activation energy	1

(Total for Question 20 = 7 marks)

Question Number	Acceptable Answers	Reject	Mark
21a	Q: C=O (1750-1735 ester saturated) **and** R: C—O (1250-1230 ethanoate) **(1)** Functional group: ester/ ethanoate **(1)**	C=O aldehyde Just O I C=O	2

Question Number	Acceptable Answers	Reject	Mark
21b(i)	(**Y** reacts with sodium carbonate to give CO_2) so is a (carboxylic) acid **(1)** M_r = 60 from mass spectrum **(1)** IGNORE Fragmentation CH_3COOH /ethanoic acid **(1)**	 CH_3COOH^+	3

Question Number	Acceptable Answers	Reject	Mark
21b(ii)	(Reacts with sodium to give H_2) so is an alcohol **and** cannot be oxidized so a tertiary alcohol ALLOW No colour change with (acidified) dichromate to justify tertiary alcohol **(1)** $(CH_3)_3COH$ ALLOW Displayed or skeletal formula 2-methylpropan-2-ol Structural, displayed or skeletal formula shown in equation **(1)** $(CH_3)_3COH + Na \rightarrow (CH_3)_3CO^{(-)}Na^{(+)} + ½ H_2$ ALLOW $C_4H_9OH + Na \rightarrow C_4H_9O^{(-)}Na^{(+)} + ½ H_2$ Multiples TE if primary or secondary alcohol given for structure **(1)**		3

Question Number	Acceptable Answers	Reject	Mark
21b(iii)	Displayed formula of $(CH_3COOC(CH_3)_3)$  ALLOW Alkyl groups not fully displayed TE on primary or secondary alcohol in b(ii)		1

Question Number	Acceptable Answers	Reject	Mark
21b(iv)	No marks for this part can be awarded unless a structure is shown in either (iii) or (iv) Two peaks because there are 2 different hydrogen environments **(1)** Relative area 3:1/ 9:3/ 1:3 /3:9 (because there are 9H in one, 3H in the other) **(1)** Both singlets **because** there are no H atoms on adjacent C / by application of n + 1 rule **(1)** ALLOW TE for ester formed from ethanoic aid and butan-1-ol / butan-2-ol ONLY For butan-1-ol 5 peaks **(1)** 3:2:2:2:3 **(1)** Singlet, triplet, pentet/quintet, sextet, triplet by application of n + 1 rule **(1)** For butan-2-ol 5 peaks **(1)** 3:3:1:2:3 **(1)** Singlet, doublet, sextet, pentet/quintet, triplet by application of n + 1 rule **(1)**		3

(Total for Question 21 = 12 marks)

TOTAL FOR PAPER = 90 MARKS