2006 Chemistry

Advanced Higher

Finalised Marking Instructions

Advanced Higher Chemistry

General information for markers

The general comments given below should be considered during all marking.

1 Marks should **not** be deducted for incorrect spelling or loose language as long as the meaning of the word(s) is conveyed.

Example: Answers like 'distiling' (for 'distillation') and 'it gets hotter' (for 'the temperature rises') should be accepted.

2 A right answer followed by a wrong answer should be treated as a cancelling error and no marks should be given.

Example: What is the colour of universal indicator in acid solution?

The answer 'red, blue' gains no marks.

3 If a right answer is followed by additional information which does not conflict, the additional information should be ignored, whether correct or not.

Example: Why can the tube not be made of copper?

If the correct answer is related to a low melting point, and the candidate's answer is 'It has a low melting point and is coloured grey' this would **not** be treated as a cancelling error.

4 Full marks should be awarded for the correct answer to a calculation on its own whether or not the various steps are shown **unless the question is structured or working is specifically asked for.**

5 A mark should be deducted in a calculation for each arithmetic slip **unless stated otherwise in the Marking Instructions.** No marks should be deducted for incorrect or missing units at intermediate stages in a calculation.

6 A mark should be deducted for incorrect or missing units **unless stated otherwise in the Marking Instructions**. Please note, for example, that KJ mol^{-1} is not acceptable for kJ mol^{-1} and a mark should be deducted.

7 Where a wrong numerical answer (already penalised) is carried forward to another step, no further penalty is incurred provided the result is used correctly.

8 No mark is given for the solution of an equation which is based on a wrong principle.

Example: Use the information in the table to calculate the standard entropy change for the reaction:

$$C_2H_2 + 2HCl \longrightarrow CH_2ClCH_2Cl$$

Compound	**S^o/J K^{-1} mol^{-1}**
C_2H_2	201
HCl	187
CH_2ClCH_2Cl	208

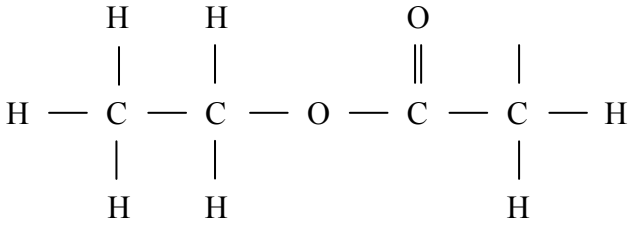
Using $\Delta S^o = S^o_{\text{reactions}} - S^o_{\text{products}}$ would gain zero marks.

9 No marks are given for the description of the wrong experiment.

10 Full marks should be given for correct information conveyed by a sketch or diagram in place of a written description or explanation.

11 In a structural formula, if one hydrogen atom is missing but the bond is shown, no marks are deducted.

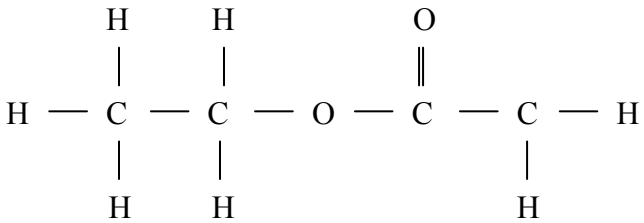
Examples:



Would not be penalised as the structural formula for ethyl ethanoate.

If the bond is also missing, then zero marks should be awarded.

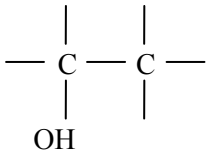
Example:



12 If a structural formula is asked for, CH_3– and CH_3CH_2– are acceptable as methyl and ethyl groups respectively.

13 With structures involving an – OH or an – NH_2 group, no mark should be awarded if the 'O' or 'N' are not bonded to a carbon, ie OH – CH_2 and NH_2–CH_2.

14 When drawing structural formulae, no mark should be awarded if the bond points to the 'wrong' atom, eg



15 A symbol or correct formula should be accepted in place of a name **unless stated otherwise in the Marking Instructions**.

16 When formulae of ionic compounds are given as answers it will only be necessary to show ion charges if these have been specifically asked for. However, if ion charges are shown, they must be correct. If incorrect charges are shown, no marks should be awarded.

17 If an answer comes directly from the text of the question, no marks should be given.

Example: A student found that 0·05 mol of propane, C_3H_8 burned to give 82·4 kJ of energy.

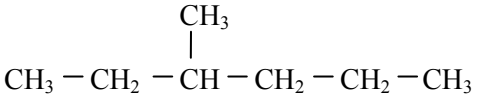
$$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(l)$$

Name the kind of enthalpy change which the student measured.

No marks should be given for 'burning' since the word 'burned' appears in the text.

18 A guiding principle in marking is to give credit for (partially) correct chemistry rather than to look for reasons not to give marks.

Example 1: The structure of a hydrocarbon found in petrol is shown below.



Name the hydrocarbon.

Although not completely correct, the answer, '3, methyl-hexane' would gain the full mark ie wrong use of commas and dashes.

Example 2: A student measured the pH of four carboxylic acids to find out how their strength is related to the number of chlorine atoms in the molecule. The results are shown.

Structural formula	**pH**
CH_3COOH	1·65
$CH_2ClCOOH$	1·27
$CHCl_2COOH$	0·90
CCl_3COOH	0·51

How is the strength of the acids related to the number of chlorine atoms in the molecule?

Again, although not completely correct, an answer like 'the more Cl_2, the stronger the acid' should gain the full mark.

Example 3: Why does the (catalytic) converter have a honeycomb structure?

A response like 'to make it work' may be correct but it is not a chemical answer and the mark should not be given.

2006 Chemistry Advanced Higher

Marking scheme

Section A

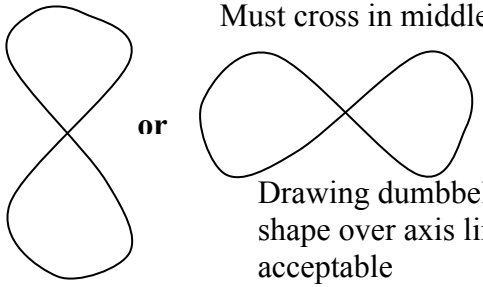
1.	D	21.	B
2.	B	22.	B
3.	A	23.	D
4.	B	24.	A
5.	A	25.	B
6.	D	26.	C
7.	C	27.	B
8.	B	28.	A
9.	B	29.	C
10.	A	30.	A
11.	C	31.	C
12.	A	32.	B
13.	D	33.	B
14.	D	34.	C
15.	C	35.	C
16.	C	36.	D
17.	D	37.	A
18.	A	38.	D
19.	B	39.	C
20.	A	40.	A

Section B

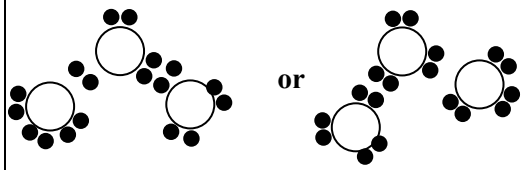
Question	Acceptable Answer	Mark	Unacceptable Answer
1 (a) (i)	+178.3 $kJmol^{-1}$ (units not required) = 178300J	1	-178.3
(ii)	+159 $J K^{-1} mol^{-1}$ (units not required) = 0.159 $kJ K^{-1} mol^{-1}$ if also have the correct answer	1	-159
(iii)	$\Delta G° = \Delta H° - T\Delta S°$ **or** $0 = \Delta H° - T\Delta S°$ (or equivalent expression) **or** $T = \Delta H°/ \Delta S°$ (1) standard signs can be omitted	1	
	$T = +178300/159$		
	T = 1121.4 K or 1121 K or 1120 K Accept correct follow through from incorrect answers to (i) and (ii) Ignore conversion to °C	1	-1 for no units or for ^{o} K - 1121.4 K = 1 out of 2 if follows on
(b) (i)	5 or V or (V) or $\overline{V}$ or +5 or 5+	1	-5 or 5-
(ii)	Calcium phosphate or calcium superphosphate or $Ca_3(PO_4)_2$ or $(Ca^{2+})_3(PO_4^{3-})_2$ Correct name/ wrong formula = 1 Calcium phosphate(V) Also accept calcium phosphate(III) if III given as answer to b (i)	1	Correct formula/wrong name dicalcium triphosphate

Question	Acceptable Answer	Mark	Unacceptable Answer
2 (a)	Colourless to purple/pink **or** Pink/purple colour remains **or** Self-indicating/MnO_4^- acts as own indicator	**1**	Clear to purple
(b)	$5C_2O_4^{2-} + 2MnO_4^- + 16H^+ \longrightarrow 10CO_2 + 2Mn^{2+} + 8H_2O$ (Accept multiples or submultiples) States not required, so ignore states	**1**	Electrons shown on either or both sides = 0 K^+ present = 0

Question	Acceptable Answer	Mark	Unacceptable Answer
(c)	No. of moles of MnO_4^- = $\frac{22.5 \times 0.020}{1000}$ = 0.00045 1 mole MnO_4^- reacts with $^5/_2$ moles $C_2O_4^{2-}$ 0.00045 mole MnO_4^- reacts with $\frac{0.00045 \times 5}{2}$ = 0.001125 c = $\frac{n}{V}$ = $\frac{0.001125}{0.025}$ = 0.045 mol l^{-1} or 0.045M or 0.045 mol/ ℓ (-1 mark if no units) Alternative methods = 1 for formula, 1 for correct substitution of values, 1 for calculation Allow correct follow through from incorrect answer to (b) For example, if no formula or explanation given and figures wrongly substituted, then candidate loses 2 marks. Marker to check arithmetic for final mark eg using pvc or cv/n and putting in wrong values for n or p 0.018 mol l^{-1} = 2 out of 3 (1:1 ratio) − working must be shown 5:2 instead of 2:5 => 0.0072 mol l^{-1} 2 out of 3 − working must be shown	**1** **1** **1**	Incorrect answer, no working = 0 marks mol^{-1} loses 1 mark Arithmetic correct but starting from "nonsense" figures eg, n= 22.5/25.0 etc

Question	Acceptable Answer	Mark	Unacceptable Answer
3 (a)	$1s^2 2s^2 2p^6$ or $[He]2s^2 2p^6$ Correct orbital box notation with labels Accept subscripts instead of superscripts	**1**	
(b)	Of equal energy/same energy Accept same energy level/orbitals of equal energy levels All in the same energy level/orbitals same energy	**1**	Similar energy Same quantum numbers cancelling errors apply eg same energy and same quantum numbers
(c)	dumbbell shape must be drawn, but must not be hybridised orbital  **or** Must cross in middle Drawing dumbbell shape over axis line is acceptable Double or triple dumbbell must be labelled correctly with p_x, p_y and p_z	**1**	Double dumbell
(d)	Two correct answers required for mark n = 3 $\ell = 0$ 3,0 3 0 30	**1**	0,3 3s *l*=3, n=0 Don't accept follow through from wrong answer in (c)

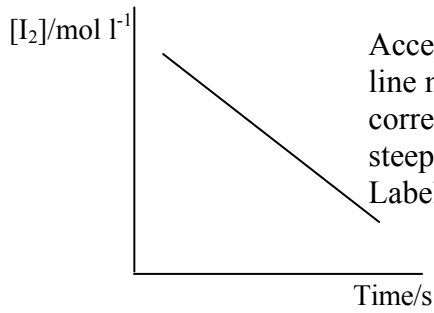
Question	Acceptable Answer	Mark	Unacceptable Answer
4 (a)	$E = \frac{Lhc}{\lambda}$ or $\lambda = \frac{Lhc}{E}$ $= (6.02 \times 10^{23})(6.63 \times 10^{-34})(3 \times 10^{8})/497000$ = 240.9 nm (units not required) but kJ mol^{-1} loses 1 mark Accept 240 - 242 $= 2.409 \times 10^{-7}$ m or nm (2 marks out of 3) 1 for formula 1 for correct substitution of **all** values in L,h,c and 1000 1 for calculation including converting m to nm To get first mark only, must relate E to λ 4.15×10^{15} =1 mark out of 3 (using $E = Lhc\lambda$) ie: $E = Lhc\lambda$ $\lambda = \frac{E}{Lhc} = \frac{497000}{6.02x10^{23} x 6.63x10^{-34} x 3x10^{8}}$ $= \frac{497000}{0.11974}$ $= 4.151 \times 10^{6}$ m $= 4.151 \times 10^{15}$ nm (1 only) $E = Lhf$ so $f = \frac{E}{Lh} = \frac{497000}{6.02x10^{23} x 6.63x10^{-34}}$ $= 1.245 \times 10^{15}$ (1 mark only) but if $\lambda = \frac{c}{f}$ also given then 2 marks out of 3	**1** **1** **1**	$E = Lhc\lambda$ lose 2 marks $E = hf$ (0 marks if nothing else given) $E = Lhf$ (0 marks if nothing else given) $E = Lh\lambda$ $E = hc/\lambda$

Question	Acceptable Answer	Mark	Unacceptable Answer
(b) (i)	-391 kJ mol^{-1} (units not required) wrong units = 0 ignore "K"	**1**	+ 391
(ii)	 **or** Double bond can also be ●●●● Acceptable if all three oxygen atoms in a straight line Ignore charges even if in wrong places Accept dots and crosses – assume that all are dots	**1**	Triangular molecule

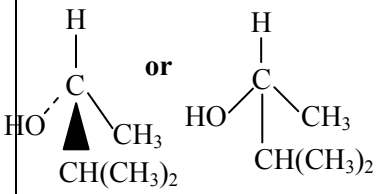
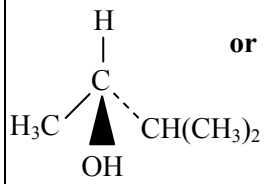
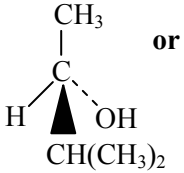
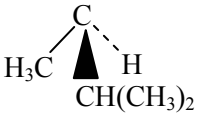
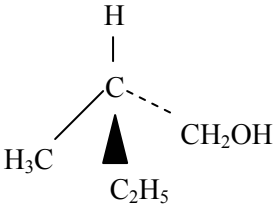
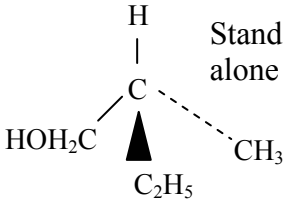
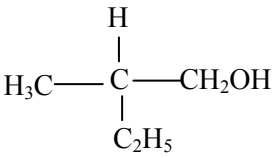
Question	Acceptable Answer	Mark	Unacceptable Answer
5 (a)	$K_a = \frac{[H^+][HPO_4^{2-}]}{[H_2PO_4^-]}$ (need correct charges here) ( ) in place of [ ] K_a can be omitted, ignore states Charges and formulae must be correct	**1**	$\frac{[\ ]+[\ ]}{[\ ]}$ wrong
(b)	pH = ½pK_a – ½logc [or multiples] = ½(7.2) – ½log(0.1) = 3.6 + 0.5 = 4.1 Can also use $[H^+] = \sqrt{(K_a \times c)}$ − for 1 mark $= 7.87 \times 10^{-5}$ = 4.1	**1** **1**	Wrong formula = 0/2 (wrong principle)
(c)	It is accepting a H^+ ion/proton or $HCO_3^- + H^+ \rightarrow (H_2O + CO_2)$ or (H_2CO_3) gaining a H^+ ion accepting a proton from $H_2PO_4^-$	**1**	$\rightarrow H_2O$ + CO or any other incorrect products (cancelling errors) neutralises the reaction any answer in terms of comparing pK_a values

Question	Acceptable Answer	Mark	Unacceptable Answer
6 (a)	Hydrogen $\Delta H = -143$ kJ (g^{-1}) Petrol $\Delta H = -44.7$ kJ (g^{-1}) or -45kJ (g^{-1}) (both required for 1 mark) (sign not required)	**1**	kJ mol^{-1}
(b) (i)	$O_2(g) + 4H^+(aq) + 4e^- \longrightarrow 2H_2O(\ell)$ Accept $\rightleftharpoons$ (or any other balanced multiples) (state symbols not required) (ignore state symbols)	**1**	Equation written in reverse even with reversible arrows
(ii)	0.03 V (units necessary)	**1**	-0.03 V

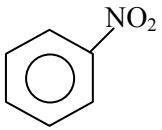
Question	Acceptable Answer	Mark	Unacceptable Answer
(iii)	$\Delta G^o = -nFE^o$ (or -nFe or –nFV) = -6 x 96500 x 1.20 = -694.8 (kJ per mole of methanol) (units not required) ignore KJ 1 for formula 1 for correct substitution of **all** values 1 for calculation including converting to kJ mol^{-1} E° = 1.2V, 2 marks for n = 1, -115.8 n = 2, -231.6 n = 4, -463.2 E° = 0.03V 2 marks for n = 1, -2.895 n = 2, -5.79 n = 4, -11.58 n = 6, -17.37 E° = 1.23V, 2 marks for n = 1, -118.695 n = 2, -237.39 n = 4, -474.78 n = 6, -712.17	**1** **1** **1**	Do not deduct mark for what is in brackets unless it is only answer given when 0 marks awarded $\Delta G^o = nFE^o$ (loses 3 marks) – wrong principle (But if given in working and – ve sign given in final answer then **acceptable**) +115.8 (0 marks) +463.2 (0 marks)

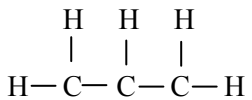
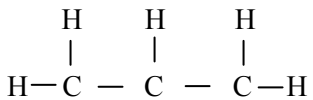
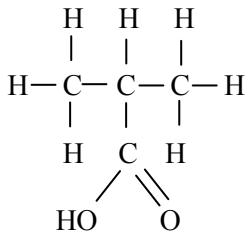
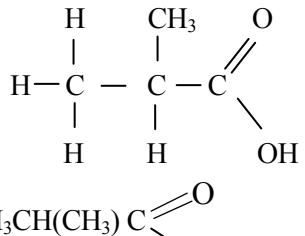
Question	Acceptable Answer	Mark	Unacceptable Answer
7 (a)	The concentrations of propanone and acid are (very) much higher than the concentration of iodine. Accept a lot higher or much larger	1	Constant/same/double/triple Higher larger
(b)	 Accept line touching axes line must be sloping correct way but ignore steepness Labels not required	1	Curve/horizontal line/diagonal in wrong direction Vertical line
(c)	Order = 2 or 2nd order	1	
(d)	$mol^{-l}\ l\ s^{-1}$ or $l\ mol^{-1}\ s^{-1}$ – or any sequence (Accept correct answer no matter answer to (c)) But follow on from wrong answer to (c), eg if Order = 0, units = $mol\ l^{-1}\ s^{-1}$ Order = 1, units = s^{-1} Order = 3, units = $l^2\ mol^{-2}\ s^{-1}$	1	

Question	Acceptable Answer	Mark	Unacceptable Answer
8 (a)	Phosphoric acid or aluminium oxide/alumina or conc sulphuric acid or orthophosphoric acid or H_3PO_4 conc orthophosphoric acid or sulphuric acid or H_2SO_4	**1**	Dilute sulphuric acid or dilute phosphoric acid or (aq) Conc H_2SO_4 and HNO_3 (cancelling errors)
(b)	Cyclohexanol contains hydrogen bonding (in O-H group) It has a greater potential for hydrogen bonding H-bonding and van der Waals forces Or correct diagram showing intermolecular forces going from O to H	**1**	Stronger intermolecular forces Cancelling errors apply here eg, *inside* molecules rather than *between* molecules Cyclohexene has hydrogen bonding
(c)	The sodium chloride is denser **or** separates the mixture better Cyclohexene less soluble in NaCl(aq) than in water or insoluble in NaCl(aq) or cyclohexene is more soluble in water Accept correct answer using salt water instead on NaCl(aq)	**1**	Cyclohexene is soluble in water Use of word 'reacts'
(d)	Making the derivative (solid/precipitate/hydrazone) Taking the melting point **and** compare with the theoretical value (or with accepted value or with the Data Book value)	**1** **1**	Check melting point (on its own without suggesting comparison)

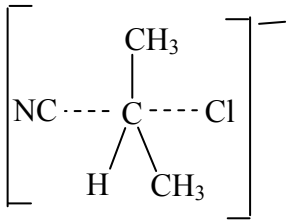
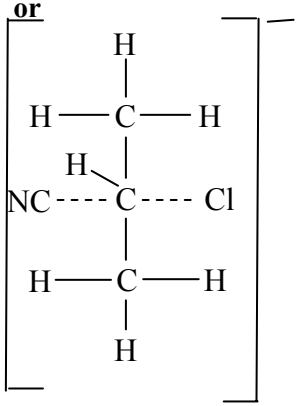
Question	Acceptable Answer	Mark	Unacceptable Answer
9 (a)	C or $(CH_3)_2(C_2H_5)COH$	1	
(b)	exchange of <u>any</u> two groups around the chirally-substituted centre gives the other optical isomer  **or** Dots and wedges not needed Must be tetrahedral shape  **or**  **or**  Accept C_3H_7 in place of $CH(CH_3)_2$	1	Lose marks for bonds to wrong symbol (however take into account that this is more difficult with wedges)
(c)	 Stand alone  (Wedges and dotted lines not needed but must indicate tetrahedral shape of A) Groups must be correct but allow bonds going to the wrong symbols Any 1 correct for 1 mark	1	

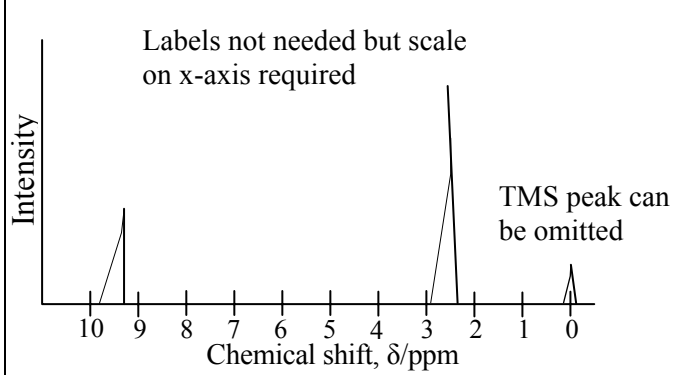
Question	Acceptable Answer	Mark	Unacceptable Answer
10 (a)	Propan-1-ol has a smaller chain length/alkyl group /hydrocarbon part or has smallest molecules OH group in Propan-1-ol makes up larger proportion of molecule (or of molecular size)		Least branching
	Propan-1-ol is **more** able to form hydrogen bonds (with the water molecules) Correct answer in terms of size, eg, the other two are bulkier molecules O – H in propan-1-ol is more polar or propan-1-ol is more polar (no explanation needed in terms of inductive effect)	**1**	Smallest mass Answer in terms of propan-1-ol being a primary alcohol
(b) (i)	Acid chloride/acyl chloride/acid anhydride C=O or (C=O instead of C=O) | | | Cl Cl OH Correct name – ignore wrong structure	**1**	Carboxyl chloride = 0 (but not a cancelling error) halide acid (but not a cancelling error) carboxyl salt (but not a cancelling error)
(ii)	More vigorous reaction/Faster reaction/Higher yield not reversible equilibrium lies further to the right reacts more readily can be done at a lower temperature Note that answer to (ii) need not follow (i)	**1**	Do not accept follow through from incorrect answer above, since cancelling errors would apply Safer/cheaper/easier made

Question	Acceptable Answer	Mark	Unacceptable Answer
11 (a) (i)	Iron(III) bromide ($FeBr_3$) Iron(III) chloride ($FeCl_3$) Aluminium bromide ($AlBr_3$) Aluminium chloride ($AlCl_3$)	**1**	Iron(II) bromide Iron(II) chloride Al_2Cl_6 } but not cancelling errors Fe_2Cl_6 }
(ii)	 **or** Nitrobenzene or dinitrobenzene etc Accept multisubstituted, and/or alternate double/single bonds instead of delocalised electrons and one or more H atoms shown on the benzene ring	**1**	No ring nor alternate double/single bonds Phenylnitrate (but not a cancelling error)
(iii)	Sulphonation/sulfonation	**1**	Sulphonification/sulphenation/sulphanation /sulphurification
(b)	In benzene, the delocalised electrons are restricted to the ring (in graphite they can move throughout the network) or can't move from molecule to molecule or the delocalised electrons are trapped in electron clouds not free to move from one molecule to another	**1**	Not free to move (on its own) Benzene has discrete molecules

Question	Acceptable Answer	Mark	Unacceptable Answer
12 (a)	 **or**  **or** $CH_3CH(CN)CH_3$ or $CH_3CHCNCH_3$	**1**	2 given, 1 correct other incorrect then CE Lose mark for bonds to wrong symbol, but only on one occasion per question
(b)	(2-)methylpropanoic acid  **or**  or $CH_3CH(CH_3)C(=O)OH$ Accept COOH, CO_2H Follow through from wrong position of CN in (a) gives butanoic acid (2 marks if correct follow through from (a) – structure and name) butanoic acid and correct structure but not a follow on from (a) – 1 mark only or ester structure + correct name = 1 mark out of 2	**1** **1**	Correct name for wrong formula = 0, unless answer fits in with $C_4H_8O_2$ eg ester structure + correct name gives 1 mark out of 2

Question	Acceptable Answer	Mark	Unacceptable Answer
(c) (i)	(2-)methylpropan-1-ol Follow through from wrong position of CN in (a) gives butan-1-ol for 1 mark	**1**	
(ii)	Acidified (potassium) dichromate **or** Acidified (potassium) permanganate **or** (Hot) copper(II) oxide	**1**	CrO_3 in pyridine Copper oxide Copper(I) Oxide Tollens' reagent Benedict's reagent

Question	Acceptable Answer	Mark	Unacceptable Answer
(d) (i)	Nucleophilic substitution	**1**	
	2 molecules determining the rate of the reaction or Where the rate determining step (RDS) /or slow step involves a collision between two particles/2nd order reaction/bimolecular	**1**	2 particles in reaction concentrations of 2 particles important for RDS
(ii)	 Must show – ve charge on central carbon or outside brackets as shown		
	or  nucleophile and leaving group need not necessarily be on opposite sides of central carbon	**1**	All 5 solid lines around central C (bond breaking and bond forming must be shown as dotted lines)

Question	Acceptable Answer	Mark	Unacceptable Answer
13 (a)	 Peaks at correct position (can be single lines) Correct ratio of height of peaks/area under peaks (peak between 0.5 and 3 ppm is **approx** three times the height/area of the peak between 9 and 10.5 ppm)	**1** **1**	
(b)	Tetramethylsilane or TMS TMS + any name close to tetramethylsilane	**1**	Tetramethylsaline (without putting in TMS)

[END OF MARKING INSTRUCTIONS]