CAMBRIDGE INTERNATIONAL AS & A LEVEL CHEMISTRY · 9701

CHEMISTRY



MARK SCHEME

17 CARBONYL COMPOUNDS

SCORE	PERCENTAGE
/	%

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Paper 1 Multiple Choice Answers: Carbonyl Compounds

Question	Paper	Q. No.	Answer
1021	9701_m22_qp_12	33	D
1022	9701_m21_qp_12	24	D
1023	9701_m21_qp_12	27	A
1024	9701_s21_qp_11	28	B
1025	9701_s21_qp_12	28	D
1026	9701_s21_qp_13	26	A
1027	9701_s21_qp_13	27	D
1028	9701_w21_qp_11	26	D
1029	9701_w21_qp_11	27	A
1030	9701_w21_qp_12	28	C
1031	9701_w21_qp_13	26	D
1032	9701_s20_qp_11	20	A
1033	9701_s20_qp_12	22	D
1034	9701_s20_qp_13	24	B
1035	9701_w20_qp_11	27	C
1036	9701_w20_qp_11	28	A
1037	9701_w20_qp_12	23	A
1038	9701_w20_qp_12	25	A
1039	9701_s19_qp_11	29	A
1040	9701_s19_qp_12	27	B
1041	9701_s19_qp_13	28	C
1042	9701_w19_qp_11	26	A
1043	9701_w19_qp_11	27	A
1044	9701_w19_qp_12	26	D
1045	9701_w19_qp_12	27	D
1046	9701_m18_qp_12	26	A
1047	9701_s18_qp_11	25	C
1048	9701_s18_qp_11	26	B
1049	9701_s18_qp_12	27	D
1050	9701_w18_qp_11	27	A
1051	9701_w18_qp_12	27	A
1052	9701_m17_qp_12	25	A
1053	9701_m17_qp_12	28	D
1054	9701_m17_qp_12	29	B
1055	9701_s17_qp_11	20	B
1056	9701_s17_qp_11	25	D
1057	9701_s17_qp_11	29	A
1058	9701_s17_qp_12	20	D
1059	9701_s17_qp_12	27	D
1060	9701_s17_qp_13	22	D
1061	9701_w17_qp_11	26	B
1062	9701_w17_qp_12	24	B
1063	9701_w17_qp_12	29	D
1064	9701_m16_qp_12	20	D
1065	9701_s16_qp_11	24	A
1066	9701_s16_qp_11	28	B

Paper 1 Multiple Choice Answers: Carbonyl Compounds (continued)

Question	Paper	Q. No.	Answer
1067	9701_s16_qp_12	26	B
1068	9701_s16_qp_12	27	A
1069	9701_s16_qp_13	22	B
1070	9701_s16_qp_13	24	D
1071	9701_w16_qp_11	26	D
1072	9701_w16_qp_11	27	B
1073	9701_w16_qp_12	25	D
1074	9701_w16_qp_12	28	B
1075	9701_s15_qp_11	20	C
1076	9701_s15_qp_12	27	A
1077	9701_s15_qp_13	24	B
1078	9701_w15_qp_11	26	A
1079	9701_w15_qp_11	27	D
1080	9701_w15_qp_11	28	B
1081	9701_w15_qp_12	23	A
1082	9701_w15_qp_12	27	B
1083	9701_w15_qp_12	28	C

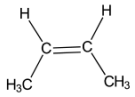
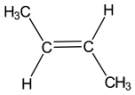
133. 9701_s21_ms_23 Q: 4

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>(a)(i)</td><td>1,3-dichloropropan(-2-)one</td><td>1</td></tr>
<tr><td>(a)(ii)</td><td>carbonyl / ketone</td><td>1</td></tr>
<tr><td>(a)(iii)</td><td>$NaBH_4$ OR $LiAlH_4$</td><td>1</td></tr>
<tr><td>(b)</td><td>
<table>
<tr><td>reagent</td><td>observation with Q</td><td>observation with R</td></tr>
<tr><td>2,4-DNPH</td><td>M1 red / orange / yellow AND precipitate / solid / crystals</td><td>M2 red / orange / yellow AND precipitate / solid / crystals</td></tr>
<tr><td>Na_2CO_3(aq)</td><td>M3 no visible change</td><td>M4 fizz / effervescence</td></tr>
</table>
</td><td>4</td></tr>
<tr><td>(c)</td><td>
<table>
<tr><td>step</td><td>reagent and conditions</td><td>type of rxn</td></tr>
<tr><td>1</td><td>M1 HCN and (trace) KCN / NaCN</td><td>M3 Addition</td></tr>
<tr><td>2</td><td>dilute sulfuric acid</td><td>Hydrolysis</td></tr>
<tr><td>3</td><td>M2 KCN/NaCN in ethanol / alcohol</td><td>M4 Substitution</td></tr>
<tr><td>4</td><td>dilute sulfuric acid</td><td>Hydrolysis</td></tr>
</table>
M5 type of reaction for step 2 AND step 4
</td><td>5</td></tr>
</table>

134. 9701_m21_ms_22 Q: 4

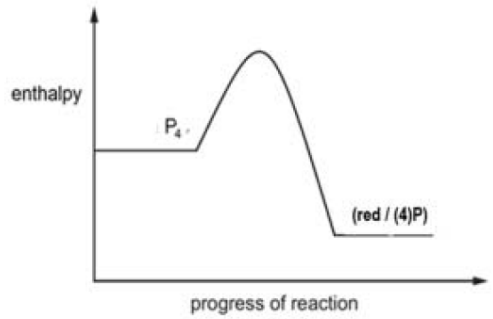
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>(a)</td><td>M1: x = 108–110°
M2: y = 118–122°</td><td>2</td></tr>
<tr><td>(b)</td><td>M1: red / orange / yellow ppt / solid
M2: silver mirror OR silver / grey / black / brown ppt / solid</td><td>2</td></tr>
<tr><td>(c)(i)</td><td>oxidising agent</td><td>1</td></tr>
<tr><td>(c)(ii)</td><td>M1: (excess dichromate and) heat under reflux
M2: to allow full oxidation (of alcohol and aldehyde groups)</td><td>2</td></tr>
<tr><td>(d)(i)</td><td>$CH_2OHCHO + 2[H] \rightarrow (CH_2OH)_2$</td><td>1</td></tr>
<tr><td>(d)(ii)</td><td>$NaBH_4$ / $LiAlH_4$</td><td>1</td></tr>
<tr><td>(d)(iii)</td><td>ethene</td><td>1</td></tr>
</table>

135. 9701_s21_ms_22 Q: 4

Question	Answer	Mark
(a)(i)	<table><tr><th></th><th>structural formula</th><th>name</th></tr><tr><td>**A**</td><td>$CH_3CH_2CH=CH_2$</td><td>but-1-ene OR 1-butene</td></tr><tr><td>**B**</td><td></td><td>cis / Z but-2-ene OR cis / Z 2-butene</td></tr><tr><td>**C**</td><td></td><td>trans / E but-2-ene OR trans / E 2-butene</td></tr><tr><td>**D**</td><td>$CH_2=C(CH_3)_2$</td><td>(2) methyl prop(-1-)ene</td></tr></table> **M1** correct identification of but-1-ene (for **A**) **M2** correct identification of but-2-ene for **B** and **C** **M3** identification of cis / trans (Z / E) for **B** and **C** (in correct order) **M4** correct name of **D**	**4**
(a)(ii)	(molecules with the) same structural formula (and same molecular formula) with different arrangement of atoms / groups in space	**1**
(b)(i)	**A**	**1**

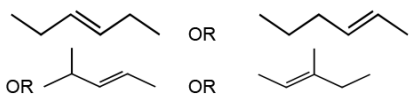
Question	Answer	Mark
(b)(ii)	 **M1** skeletal formula only	**1**
	M2 *explanation in terms of increased / greater stability of intermediate / carbocation* intermediate / (secondary) carbocation / $CH_3C^+(H)(CH_2CH_3)$ is (more) stable	**1**
	M3 *reason for increased stability of intermediate in terms of greater number of alkyl groups showing largest inductive (electron releasing) effect* greater (positive) inductive effect due to two alkyl groups OR greater electron donation of two alkyl groups	**1**
(c)	dehydrating agent / cause dehydration	**1**
(d)(i)	oxidation	**1**
(d)(ii)	<table><tr><td>functional group</td><td>present in **Z**</td></tr><tr><td>aldehyde</td><td>✓</td></tr><tr><td>ketone</td><td></td></tr><tr><td>carboxylic acid</td><td></td></tr></table>	**1**

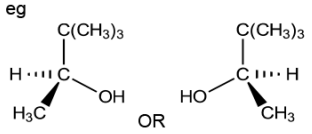
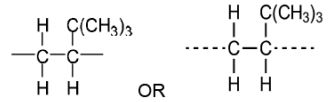
136. 9701_w21_ms_21 Q: 3

Question	Answer	Marks
(a)(i)	**M1** simple molecular **M2** giant molecular **M3** weak IMFs (overcome) in P_4 **AND** strong (covalent) bonds (broken) in P	3
(a)(ii)		1
(b)(i)	(+)5/V	1
(b)(ii)	$PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$ $P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$	2
(c)(i)	$C_{18}H_{15}P$	1
(c)(ii)	stage 1 = reduction stage 2 = substitution	2

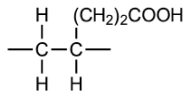
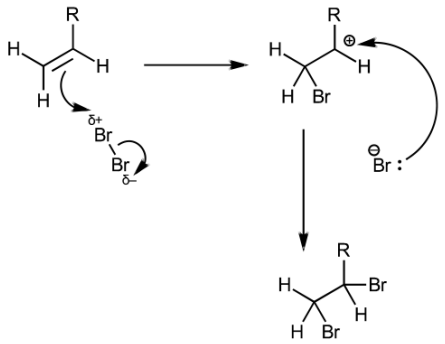
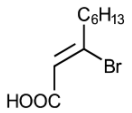
Question	Answer		Marks
(c)(iii)	**G** = $C_2H_5CH_2OH$	**H** = $C_2H_5CH{=}CHC_2H_5$	2
(d)	$CH_3CH_2CO_2H$	CH_3COCH_3	2

137. 9701_w21_ms_22 Q: 3

Question	Answer	Marks
(a)	(2,3-)dimethylbut-2-ene	1
(b)		1
(c)(i)		1
(c)(ii)	sp^2	1
(d)(i)	cold dilute acidified potassium manganate(VII)	1
(d)(ii)	**M1** (2,4-DNPH will produce a) red / orange / yellow precipitate **M2 V** has a carbonyl group	2
(d)(iii)	**M1** C—O in range 1040–1300 (cm^{-1}) **M2** C=O in range 1670–1740 (cm^{-1})	2
(e)(i)	yellow precipitate	1
(e)(ii)	Iodine / I_2	1
(e)(iii)	$C_6H_{12}O + 2[H] \rightarrow C_6H_{14}O$	1

Question	Answer	Marks
(e)(iv)	Draw two optical isomers of X. eg  **M1** *One correct 3-dimensional representation of X* **M2** *3-d structure which represents the enantiomer of their X*	1 1
(e)(v)	heat **AND** concentrated H_2SO_4 / concentrated H_3PO_4 / concentrated sulfuric [(VI)] acid / concentrated phosphoric[(V)] acid	1
(e)(vi)		1
(e)(vii)	high activation energy	1

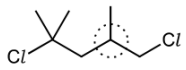
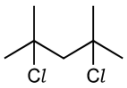
138. 9701_m20_ms_22 Q: 3

(a)(i)	**M1** acidified / H^+ $Cr_2O_7^{2-}$ / (potassium / sodium) dichromate OR manganate(VII) / MnO_4^- / $KMnO_4$ **M2** (heat under) reflux	**2**
(a)(ii)	nucleophilic addition	**1**
(a)(iii)	yellow / orange / red ppt / solid	**1**
(a)(iv)	it does not have four different (groups of) atoms attached to (central) carbon OR it does not have a chiral carbon / centre OR it has two identical / COOH groups attached to (central) carbon OR mirror image is super(im)posable	**1**
(a)(v)	**M1** hydrolysis **M2** esterification / condensation	**2**
(b)(i)	**M1** no. of mol $O_2 = \frac{1.00\times10^5\times1.06\times10^{-3}}{(8.31\times850)}$ **M2** no. of mol of nitroglycerine = $4\times0.0150 = 0.0600$ (mol) **M3** mass of nitroglycerine = $0.0600\times227 = 13.6(2)$ (g)	**3**
(b)(ii)	$1.06\times29 = 30.7(4)$ dm^3	**1**
(c)(i)	$C_5H_8O_2$	**1**
(c)(ii)		**1**
(c)(iii)	 **M1** curly arrow from C=C double bond to Br **M2** correct dipole in Br_2 **AND** curly arrow from Br—Br to $Br^{\delta-}$ **M3** correct intermediate **AND** curly arrow from lone pair on Br^- to C^+ **M4** correct product	**4**
(d)(i)	**M1**  **M2** (two) different groups on each C atom in the C=C / end of the C=C double bond **M3** no / restricted rotation about C=C	**3**
(d)(ii)	H_2 / hydrogen	**1**
(d)(iii)	**M1 / M2** *absorptions seen in both spectra (any two):* (same) both show an absorption at 1680–1730 (cm^{-1}) because of C=O (same) both show an absorption at 1040–1300 (cm^{-1}) because of C–O (same) both show an absorption at 2500–3000 (cm^{-1}) because of RCO_2–H / O–H in RCO_2H / carboxyl(ic acid) **M3** *absorption only seen in spectrum of* **T***:* (different) **T** shows an absorption at 1500–1680 (cm^{-1}) because of C=C (different) **T** shows an absorption at 3000–3100 (cm^{-1}) because of (C=)C–H	**3**

139. 9701_s20_ms_21 Q: 5

(a)(i)	C*l*	**1**
(a)(ii)	HC*l* **AND** H_2O	**1**
(a)(iii)	**M1** CO_3^{2-} **M2** propanoic acid – effervesce. (Propan-1-ol – no reaction)	**2**
(b)(i)	ultraviolet light / uv	**1**
(b)(ii)	homolytic fission (of chlorine (gas) / Cl_2)	**1**
(c)(i)	carbonyl / aldehyde / ketone	**1**
(c)(ii)	tertiary halogenoalkane	**1**
(d)(i)	*Two structures representing the intermediate* **M1** $C_2H_5C^+HCH_3$ **M2** $CH_3CH_2CH_2C^+H_2$	**2**
(d)(ii)	*Identify the most stable intermediate* **M1** $C_2H_5C^+HCH_3$ *explanation* **M2** (more / 2 alkyl groups attached so) it has the greater inductive / electron donating effect	**2**

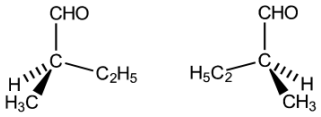
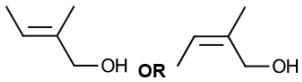
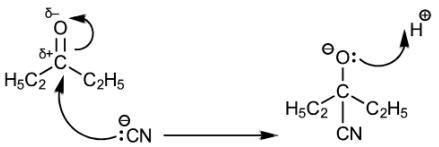
140. 9701_w20_ms_22 Q: 3

(a)(i)	$P_4 + 10Cl_2 \rightarrow 4PCl_5$	**1**
(a)(ii)	simple / molecular AND covalent	**1**
(b)(i)	steamy / misty fumes	**1**
(b)(ii)	$PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$	**1**
(b)(iii)	0 to 4	**1**
(c)(i)	$LiAlH_4$ OR lithium tetrahydridoaluminate((III))	**1**
(c)(ii)	**M1:** molecule with a non super-(im)posable mirror image	**2**
	M2: 	
(c)(iii)		**1**
(d)(i)	**M1:** (trigonal) pyramidal	**2**
	M2: 107	
(d)(ii)	**M1:** proton / H^+ donor	**2**
	M2: partially dissociates (in solution)	
(d)(iii)	**method 1** **M1:** *show the number of mol gas produced from 0.241 g NCl_3* *[$M_r(NCl_3)$ = 120.5 1 mol NCl_3 produces 2 mol gas]* $n = 2 \times 0.241 / 120.5$ OR $n = 0.0040$ (mol gas produced.)	**4**
	M2: *correct conversion of T to Kelvin, V to m^3 and correct value of R*	
	M3: *use of equation P = nRT / V with M2 values for n, R, T and V to find pressure of mol gas produced* increase in $p = nRT/V = \frac{0.0040 \times 8.31 \times 293}{250 \times 10^{-6}}$ $= 3.90 \times 10^4$	
	M4: = *1.00 × 10^5 + M3 (Pa)* total pressure $= 1.00 \times 10^5 + 3.90 \times 10^4$ $= 1.39 \times 10^5$ (Pa)	
	method 2 **M1:** *calculate the produced from 0.241 g NCl_3* 0.003 (mol) Cl_2 **AND** 0.001 (mol) N_2	
	M2: *conversion of T to Kelvin, V to m^3 and correct value of R in all PV/RT equations used* **M3:** *use of equation PV / RT= n for both calculations or a combined equation with M2 values for R,T and V to find partial pressure for each of the gases* *pp*Cl_2 = 29217.96 AND *pp*N_2 = 9739.32	
	M4: *Use P_{total} = pp unreacted gas + ppCl_2 + ppN_2* $1 \times 10^5 + 2.92 \times 10^4 + 9.74 \times 10^3 = 138\,940$	

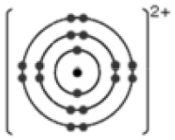
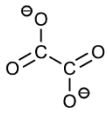
141. 9701_s19_ms_21 Q: 4

<table>
<tr><td>(a)</td><td>3-chloroprop-1-ene</td><td>1</td></tr>
<tr><td>(b)</td><td>a = 109(.5)°</td><td>1</td></tr>
<tr><td></td><td>b = 120°</td><td>1</td></tr>
<tr><td>(c)(i)</td><td>$C_3H_7ClO_2$</td><td>1</td></tr>
<tr><td>(c)(ii)</td><td>oxidation</td><td>1</td></tr>
<tr><td>(c)(iii)</td><td><table><tr><td></td><td>alcohol group present in Z</td></tr><tr><td>primary</td><td>✓</td></tr><tr><td>secondary</td><td>✓</td></tr><tr><td>tertiary</td><td></td></tr></table></td><td>1</td></tr>
<tr><td>(d)(i)</td><td>A and B</td><td>1</td></tr>
<tr><td>(d)(ii)</td><td><table><tr><td></td><td>Compound(s)</td><td>Observation</td></tr><tr><td>Reaction with Tollens' reagent</td><td>B ✓</td><td>silver mirror
OR grey / black / brown / silver precipitate ✓</td></tr></table></td><td>2</td></tr>
<tr><td></td><td><table><tr><td></td><td>Compound(s)</td><td>Observation</td></tr><tr><td>Reaction with alkaline aq. iodine</td><td>A ✓ and C ✓</td><td>(Pale) yellow precipitate /solid ✓</td></tr></table></td><td>3</td></tr>
<tr><td></td><td><table><tr><td></td><td>Compound(s)</td><td>Observation</td></tr><tr><td>Reaction with sodium metal</td><td>C ✓ and D✓</td><td>Effervescence / sodium/solid disappears ✓</td></tr></table></td><td>3</td></tr>
</table>

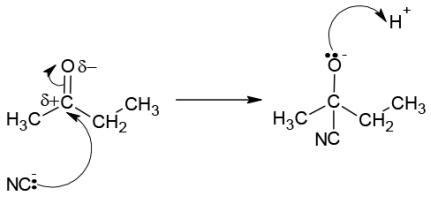
142. 9701_w19_ms_21 Q: 4

(a)(i)	(2,2–)dimethylpropanal	1
(a)(ii)	sp^2	1
(b)(i)	acidified potassium dichromate**[(VI)] AND** heat under reflux	1
(b)(ii)	**M1: A** has **H-bonding** (between molecules) **M2: B** only has dipole–dipole / **VdW** forces (between molecules) **M3:** H-bonding is stronger / requires more energy to overcome	3
(b)(iii)	$(CH_3)_3CCHO + 2[H] \rightarrow (CH_3)_3CCH_2OH$	1
(b)(iv)	 **M1:** / $CH_3CH(OH)CH_3$ **M2:** H_2SO_4 / sulfuric acid	2
(c)(i)	• orange / red / yellow precipitate • orange / red / yellow precipitate	1
(c)(ii)	Aldehyde	1
(c)(iii)	has a carbon / atom attached / bonded to four different atoms / groups / groups of atoms / chains	1
(c)(iv)	 **M1:** Correct 3D representation **M2:** Correct 3D representation of drawn enantiomer	2
(c)(v)	principal absorptions in the infra-red spectrum / bond responsible 3200–3600 cm^{-1} / RO-H / O-H 1630 cm^{-1} / C=C 1050 cm^{-1} / C—O	1
(c)(vi)	 **M1:** skeletal alkene group **AND** C5 structure **M2: one** alcohol group **M3:** branched chain **AND** capable of geometrical isomerism	3
(c)(vii)	**M1:** Correct structure of **X** and correct dipole on C=O **M2:** curly arrow from C=O bond to O AND intermediate with CN attached and –ve charge on the O **M3:** curly arrow from lone pair on CN^- to C(=O) in **X** **AND** curly arrow from lone pair in the intermediate to H^+ 	3
(c)(viii)	catalyst	1

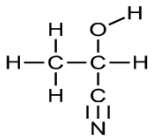
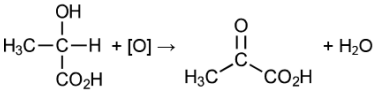
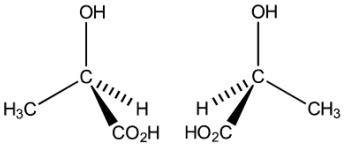
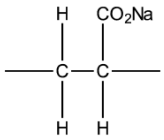
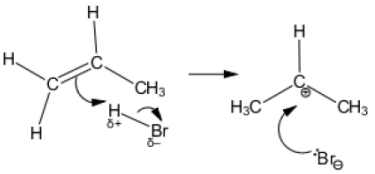
143. 9701_m18_ms_22 Q: 3

(a)(i)	$Ca + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2$	**1**
(a)(ii)	$CaSO_4$ does not react (with sulfuric acid) coating / crust / protective layer / $CaSO_4$ prevents reaction (of sulfuric acid) with calcium	**2**
(b)(i)	 dot-and-cross diagram **AND** 2+	**1**
(b)(ii)	 displayed structure of ethanedioate two – charges on carboxylates **OR** 2– charge overall	**2**
(c)(i)	bleach	**1**
(c)(ii)	$Cl_2 + 2OH^- \rightarrow Cl^- + ClO^- + H_2O$	**1**
(c)(iii)	–1 **AND** (+)5	**1**
(c)(iv)	gains **AND** loses electrons	**1**
(d)(i)	carbon dioxide **AND** water	**1**
(d)(ii)	<table><tr><th>reaction</th><th>reagent(s) and condition(s)</th></tr><tr><td>**1**</td><td>HCN ✓ NaCN ✓</td></tr><tr><td>**3**</td><td>□ $K_2Cr_2O_7$ □ H_2SO_4 / acid / H^+ □ (heat under) reflux</td></tr></table>	**4**
(d)(iii)	hydrolysis	**1**
(d)(iv)	reducing agent	**1**
(d)(v)	has a carbon / C / atom attached to four different groups / atoms / chains **OR** has no plane / line of symmetry / has non-superimposable images	**1**

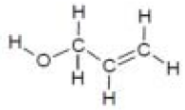
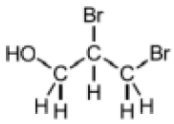
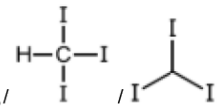
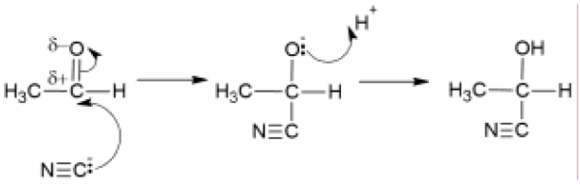
144. 9701_s18_ms_22 Q: 4

(a)(i)	iodoform / tri-iodomethane	1
(a)(ii)	butanone	1
(b)	$CH_3CH_2CH_2CHO$	1
	$(CH_3)_2CHCHO$	1
(c)(i)	reduction	1
(c)(ii)	$NaBH_4$ / sodium borohydride OR $LiAlH_4$ / lithium aluminium hydride	1
(d)(i)		
	lone pair on C of CN^- and curly arrow to C of C=O	1
	correct dipole on C=O and curly arrow from = to O	1
	correct intermediate anion	1
	curly arrow from lone pair on O to H^+	1
(d)(ii)	optical	1
(d)(iii)	(X has a) chiral centre / asymmetric carbon atom OR (X has a) C atom attached to four different groups / atoms / chains	1
	non-super(im)posable mirror images	1
(e)(i)	*M1 is for the process of taking the % of each element and dividing by its relative atomic mass.* C: $\frac{51.3}{12}$ H: $\frac{9.40}{1}$ N: $\frac{12.0}{14}$ O: $\frac{27.3}{16}$ OR 4.28 9.40 0.857 1.71 *M2 is for dividing the smallest %/A_r into each of the remaining values to produce the correct ratio.* $\frac{4.28}{0.857}$ $\frac{9.40}{0.857}$ $\frac{0.857}{0.857}$ $\frac{1.71}{0.857}$ OR 4.9942 : 10.9685 : 1 : 1.9953	2
(e)(ii)	$C_5H_{11}NO_2$ **AND** because the EFM = RFM	1

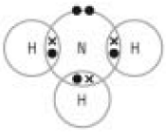
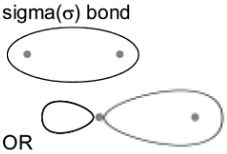
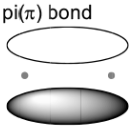
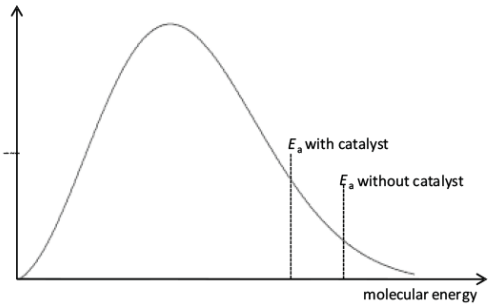
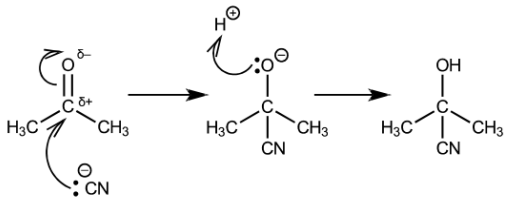
145. 9701_w18_ms_22 Q: 4

(a)(i)		**1**
(a)(ii)	dehydration	**1**
(a)(iii)		**1**
(a)(iv)	$Na_2Cr_2O_7$ / $K_2Cr_2O_7$ **AND** (dilute) H_2SO_4 / H^+(aq) / acidified	**1**
(b)(i)	(Molecules that are) non-super(im)posable mirror images	**1**
(b)(ii)	 **M1** correct 3-d drawing of one isomer of Q [1] **M2** correct pair of 3-d structures of the optical isomers of Q [1]	**2**
(c)	 OR $-CH_2CH(CO_2Na)-$	**3**
(d)(i)	**M1** I experiences a (greater positive) inductive effect due to more alkyl groups OR I contains more electron donating alkyl groups (than II) [1] **M2** which stabilises the charge / reduces the charge (on the ion/intermediate) OR spreads the charge across the ion / molecule / intermediate [1]	**2**
(d)(ii)	 **M1** curly arrow from double bond to H of H—Br [1] **M2** curly arrow from H—Br bond to Br **AND** correct dipole on H—Br [1] **M3** curly arrow from lone pair on Br^- to C^+ [1]	**3**
(d)(iii)	nucleophilic substitution	**1**
(e)(i)	$CH_3COCO_2H + 6[H] \rightarrow CH_3CHOHCH_2OH + H_2O$ **M1** correct organic product $CH_3CHOHCH_2OH$ [1] **M2** [H] present as reactant with H_2O as product and balancing [1]	**2**
(e)(ii)	$1s^2\ 2s^2\ 2p^6\ (3s^0)$	**1**
(e)(iii)	Ions/elements have more shells / energy levels (as the group is descended)	**1**

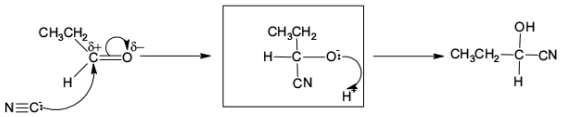
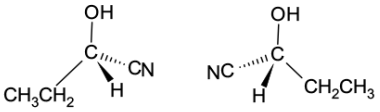
146. 9701_s17_ms_21 Q: 4

(a)(i)	(molecules / isomers with) the same molecular formula / same number of atoms of each element	1
	different structural / displayed formulae / arrangement of bonds	1
(a)(ii)	sp^2 overlap of (2)s with two (2)p (atomic) orbitals	1
	sp^3 overlap of (2)s with all three (2)p (atomic) orbitals	1
(a)(iii)	$sp^2 = 116° – 124°$	1
	$sp^3 = 106° – 112°$	1
(b)(i)		1
(b)(ii)	(electrophilic) addition	1
	bromine decolourises / turns colourless / fades (from orange / brown)	1
(b)(iii)	$HOCH_2CHBrCH_2Br$ OR 	1
(b)(iv)	CO_2 / carbon dioxide	1
(c)(i)	**P** = propanal	1
	Q = propanone	1
(c)(ii)	tr(i)iodomethane / CHI_3 / 	1
(d)(i)	(molecules / isomers with) the same (molecular and) structural formula	1
	Any two of: chiral centre / C attached to four different groups / atoms non-super(im)posable mirror images different spatial / 3D arrangement of atoms (owtte) different rotation of plane-polarised light	1
(d)(ii)		
	curly arrow from lone pair on :C≡N to $C^{(\delta+)}$	1
	correct dipole on carbonyl $^{\delta+}C{=}O^{\delta-}$ AND curly arrow from bond to $O^{(\delta-)}$	1
	correct intermediate, including $C–O^-$ AND curly arrow from lone pair to H^+	1
	Total:	**19**

147. 9701_m16_ms_22 Q: 3

(a) (i)	 three bonding pairs lone pair AND octet shape = (trigonal) pyramidal	 [1] [1] [1]
(ii)	sigma(σ) bond  OR pi(π) bond 	[1] [1]
(b) (i)	forward and backward reactions occurring <u>at same rate</u> OR <u>the rate of</u> forward and backward reactions are equal	[1]
(ii)	M1 = decreased yield of products / less products formed / ora M2 = l<u>eft</u>-hand side has fewer moles of gas OR equilibrium shifts to the <u>left</u>	[1] [1]
(c)	 M1 = correct Boltzmann curve M2, M3 any 2 from: • line for **both** E_a values or statement in text that catalyst lowers E_a • (catalyst) increases proportion/number of molecules/particles with energy ⩾ activation energy • so more frequent successful collisions	 [1] [1] [1]
(d) (i)	nucleophilic addition	[1]
(ii)	 correct dipole on carbonyl curly arrow from lone pair on CN^- AND from C=O to O correct intermediate curly arrow from lone pair on O^- to H^+ correct product	 [1] [1] [1] [1] [1]

148. 9701_s16_ms_22 Q: 5

(a) (i)	acidified / H^+ AND potassium / sodium dichromate	 [1]
(ii)	distillation (rather than reflux) (ensures aldehyde escapes) to avoid further oxidation / to avoid forming acid / as reflux causes further oxidation	[1] [1]
(b)	reaction 3 – (conc) H_2SO_4 / (conc) H_3PO_4 or Al_2O_3 / pumice / porcelain / porous pot / ceramic AND heat reaction 4 – KBr / NaBr with (conc) H_2SO_4 or (red)P and Br_2 / PBr_3 AND heat	 [1] [1]
(c) (i)	 M1 = lone pair on C of CN^- AND curly arrow from lone pair to carbonyl carbon M2 = dipole on C=O AND curly arrow to O from = M3 = intermediate with negative charge M4 = lone pair and curly arrow to H^+	 [1] [1] [1] [1]
(ii)		[1+1]
(iii)	attack / attach from either side / above or below / from two directions because the carbonyl / molecule is planar / trigonal / flat / because of the shape of the molecule OR product is chiral / has a chiral carbon / has a carbon attached to four different groups / has a chiral centre / is asymmetric (equal) chance of forming either (of the two optical isomers) / mechanism doesn't distinguish between the two (optical isomers) / able to form either / chance of forming / able to form 50:50 OR because the carbonyl / molecule is planar / trigonal / flat OR because of the shape of the molecule (equal) chance of forming either (of the two optical isomers) / mechanism doesn't distinguish between the two (optical isomers) / able to form either / chance of forming / able to form 50:50	[1] [1]

149. 9701_w16_ms_21 Q: 5

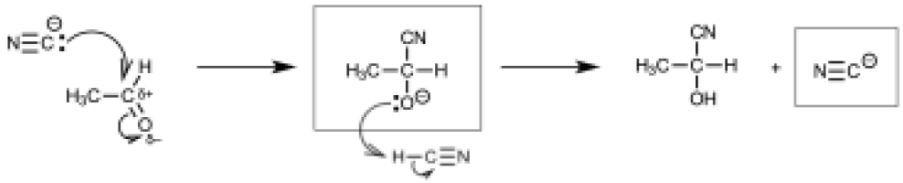
(a)		1	**1**
(b)	$H^+ / Cr_2O_7^{2-}$ (heat under) reflux	1 1	**2**
(c)	$H^+ / Cr_2O_7^{2-}$ (heat and) distil	1 1	**2**
(d)	(1-)propyl propanoate	1	**1**
	Total:		**6**

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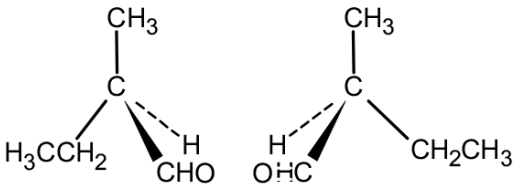
150. 9701_w16_ms_22 Q: 5

(a)(i)	$Cl\bullet$ and $\bullet CH_3$	**1**
(a)(ii)	Cl^- and $^+CH_3/CH_3^+$	**1**
(b)(i)	Oxidation **OR** reduction	**1**
(b)(ii)	Condensation	**1**
(b)(iii)	Reduction **OR** oxidation **OR** addition	**1**
(b)(iv)	Addition	**1**
	Total:	**6**

151. 9701_S15_ms_21 Q: 3

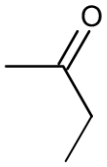
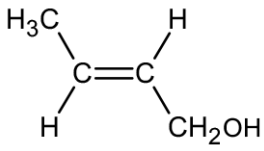
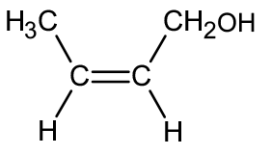
(a)	Bond breaking = C=O = 740 C–H = 410 = 1150 kJ Bond forming = C–C = 350 C–O = 360 O–H = 460 = 1170 kJ Enthalpy change = 1150 – 1170 = **–20** kJ mol^{-1}	[1] [1] [1]
(b) (i)	Stereoisomerism = (molecules with the same molecular formula and) same structural formula but different spatial arrangements of atoms Chiral centre = atom with four different atoms/groups attached	[1] [1]
(ii)	(Planar) carbonyl so (equal chance of nucleophile) attacking either side	[1]
(c) (i)	 M1 = lone pair **AND** curly arrow from lone pair to carbonyl C M2 = partial charges on C=O **AND** curly arrow from bond (=) to $O^{\delta-}$ M3 = structure of intermediate including charge M4 = lone pair **AND** two correct curly arrows (from lone pair to H **AND** from H—C to C) M5 = CN^-	[1] [1] [1] [1] [1]
(ii)	(CN^- regenerated so) catalyst	[1]

152. 9701_S15_ms_22 Q: 4

(a) (i)	**A** = $CH_3CH_2CH_2CH_2CHO$	[1]
	B = $CH_3CH_2CH(CH_3)CHO$	[1]
	C = $(CH_3)_2CHCH_2CHO$	[1]
	D = $(CH_3)_3CCHO$	[1]
(ii)		[1+1]
(b) (i)	Fehling's / Benedict's **OR** Tollens' **OR** dichromate **OR** manganate	[1]
	Warm / heat	[1]
	Fehling's / Benedict's =(Brick)-red ppt Tollens' = silver / mirror **OR** grey/black precipitate Dichromate = orange to green Manganate = purple to colourless — with the aldehyde / A-D	[1]
(ii)	(2,4-)DNP(H) / Brady's reagent	[1]
	Orange / yellow / red-orange / yellow-orange ppt	[1]

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153. 9701_S15_ms_23 Q: 3

<table>
<tr><td>(a) (i)</td><td>A/B = 
C = </td><td>[1]
[1]
[1]</td></tr>
<tr><td>(ii)</td><td>Chain</td><td>[1]</td></tr>
<tr><td>(iii)</td><td>Silver mirror/ppt/solid (black/grey)</td><td>[1]</td></tr>
<tr><td>(b) (i)</td><td>
<table>
<tr><td>D
$CH_2=C(CH_3)CH_2OH$</td><td></td></tr>
<tr><td>E

trans OR E</td><td>E

cis OR Z</td></tr>
<tr><td>F
$H_2C=CHCH_2CH_2OH$</td><td></td></tr>
</table>
</td><td>[1]
[1+1]
[1]
[1]</td></tr>
<tr><td>(ii)</td><td>Hydrogen</td><td>[1]</td></tr>
<tr><td>(c) (i)</td><td>$C_3H_6O + [O] \rightarrow C_3H_6O_2$</td><td>[1]</td></tr>
<tr><td>(ii)</td><td>$C_3H_6O + 2[H] \rightarrow C_3H_8O$</td><td>[1]</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>