
CHEMISTRY

9701/21

Paper 2 AS Level Structured Questions

May/June 2016

MARK SCHEME

Maximum Mark: 60

Published

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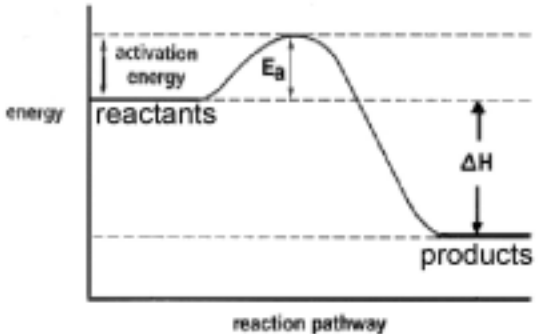
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Question	Mark Scheme							Mark	Total
1 (a)	name of element	nucleon no.	atomic no.	no. of protons	no. of neutrons	no. of electrons	overall charge		
	lithium	6	3	3	3	2	+1	[1]	[4]
	oxygen	17	8	8	9	10	−2	[1]	
	iron	54	26	26	28	24	+2	[1]	
	chlorine	35	17	17	18	17	0	[1]	
(b)	line straight on labelled ‘neutrons’ line (curving) up labelled ‘protons’ proton line clearly shows less (overall) deflection than electron curve							[1] [1] [1]	[3]
(c) (i)	Group 16/6/VI AND Big (owtte) increase/big difference/big gap/big jump/jump in increase/jump in difference after 6th IE							[1]	[1]
(ii)	increases (across period) due to increasing attraction (of nucleus for electrons) due to increasing nuclear charge/atomic/proton number AND constant/similar shielding/same (outer/number of) shell/energy level							[1] [1]	[2]
(iii)	electron (pair) repulsion (Y has a) pair of electrons in a (3)p orbital/a (3)p orbital is full ORA							[1] [1]	[2]
(iv)	(1s ²)2s ² 2p ⁶ 3s ² 3p ⁵							[1]	[1]
(d) (i)	0.56(%)							[1]	[1]

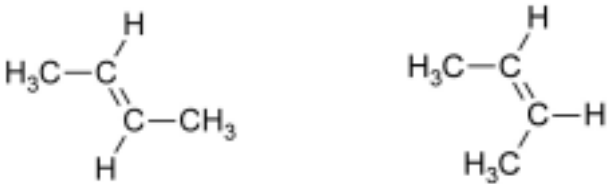
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Question	Mark Scheme	Mark	Total
(ii)	$\frac{(A \times 0.56) + (86 \times 9.86) + (87 \times 7.00) + (88 \times 82.58)}{100} = 87.71$ A = 84	[1] [1]	[2]
			[16]
2 (a)	D = Ga G = Se	[1]	[1]
(b) (i)	$\text{D}_2\text{O}_3 + 6\text{HCl} \rightarrow 2\text{DCl}_3 + 3\text{H}_2\text{O}$ M1 = species; M2 = balancing	[1] [1]	[2]
(ii)	$\text{D}_2\text{O}_3 + 2\text{NaOH} + 7\text{H}_2\text{O} \rightarrow 2\text{NaD}(\text{OH})_4(\text{H}_2\text{O})_2$ OR $\text{D}_2\text{O}_3 + 2\text{NaOH} + 3\text{H}_2\text{O} \rightarrow 2\text{NaD}(\text{OH})_4$ OR $\text{D}_2\text{O}_3 + 2\text{NaOH} \rightarrow 2\text{NaDO}_2 + \text{H}_2\text{O}$ OR $\text{D}_2\text{O}_3 + 2\text{OH}^- + 7\text{H}_2\text{O} \rightarrow 2[\text{D}(\text{OH})_4(\text{H}_2\text{O})_2]^-$ OR $\text{D}_2\text{O}_3 + 2\text{OH}^- + 3\text{H}_2\text{O} \rightarrow 2[\text{D}(\text{OH})_4]^-$ OR $\text{D}_2\text{O}_3 + 2\text{OH}^- \rightarrow 2\text{DO}_2^- + \text{H}_2\text{O}$ M1 = species; M2 = balancing	[1] [1]	[2]
(c)	giant ionic/ionic lattice	[1]	[1]
(d)	$\text{GO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{GO}_3$	[1]	[1]
			[7]

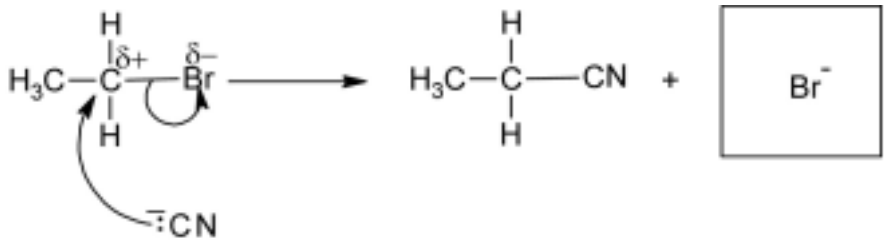
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Question	Mark Scheme	Mark	Total
3 (a) (i)	bubbles / effervescence / fizzing calcium gets smaller / disappears water turns cloudy / milky calcium sinks	[1] [1] [1] [1]	max [3]
(ii)	$\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + \text{H}_2$	[1]	[1]
(iii)	faster bubbling / disappearance of Ba OR no / less precipitate forms (owtte)	[1]	[1]
(b) (i)	 M1 – general layout with products below reactants AND both labelled M2 – E_a and ΔH / energy change / released labelled with vertical lines	 [1] [1]	[2]
(ii)	activation energy is high so few/no particles with $E \geq E_a$	[1] [1]	[2]

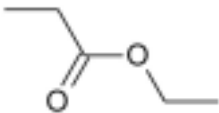
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Question	Mark Scheme	Mark	Total
(iii)	high melting / boiling point strong forces (of attraction / between oppositely charged ions) / strong (ionic) bonding	[1] [1]	[2]
(iv)	MgO is basic / reacts with acid	[1]	[1]
(c) (i)	increases (down the group)	[1]	[1]
(ii)	$\text{MgCO}_3 \rightarrow \text{MgO} + \text{CO}_2$	[1]	[1]
(iii)	$2\text{Ca}(\text{NO}_3)_2 \rightarrow 2\text{CaO} + 4\text{NO}_2 + \text{O}_2$	[1]	[1]
			[15]
4 (a)	$\text{CH}_2=\text{CHCH}_2\text{CH}_3 / \text{CH}_2\text{CHCH}_2\text{CH}_3$ AND $\text{CH}_3\text{CH}=\text{CHCH}_3 / \text{CH}_3\text{CHCHCH}_3$	[1]	[1]
(b)	$\text{CH}_2=\text{CHCH}_2\text{CH}_3 / \text{CH}_2\text{CHCH}_2\text{CH}_3$ AND $(\text{CH}_3)_2\text{C}=\text{CH}_2 / (\text{CH}_3)_2\text{CCH}_2$	[1]	[1]
(c)	 <i>trans</i> -but-2-ene (or <i>E</i>) <i>cis</i> -but-2-ene (or <i>Z</i>)	[1] [1]	[2]

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Question	Mark Scheme	Mark	Total
(d)	B is $\text{CH}_2=\text{CHCH}_2\text{CH}_3$ OR $\text{CH}_3\text{CH}=\text{CHCH}_3$ OR $(\text{CH}_3)_2\text{C}=\text{CH}_2$ distinguished by addition of bromine brown/red/orange/yellow to colourless/decolourises with B (but not A)	[1] [1] [1]	[3]
			[7]
5 (a)	 M1 = lone pair on C of CN^- AND curly arrow from lone pair to C of $\text{C}-\text{Br}$ M2 = correct dipole on $\text{C}-\text{Br}$, curly arrow from $\text{C}-\text{Br}$ bond to Br AND Br^-	[1] [1]	[2]
(b) (i)	reduction	[1]	[1]
(ii)	disappearance of peak / dip / trough / absorption at 1680–1730 due to (loss of) $\text{C}=\text{O}$ OR peak at 3200–3650 due to (alcohol) $\text{O}-\text{H}$ (formation)	[1] [1] [1] [1]	[2]
(c) (i)	sodium/potassium hydroxide aqueous	[1] [1]	[2]

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Question	Mark Scheme	Mark	Total
(ii)	ethanol	[1]	[1]
(d) (i)	(conc) H ⁺ / (conc) acid / (conc)H ₂ SO ₄ / (conc)H ₃ PO ₄	[1]	[1]
(ii)		[1]	[1]
(iii)	ethyl propanoate	[1]	[1]
(e) (i)	V = CH ₃ CH ₂ CHCHCH ₂ CH ₃ / CH ₃ CH ₂ CH=CHCH ₂ CH ₃ T = CH ₃ CH ₂ CH(OH)CH(OH)CH ₂ CH ₃	[1] [1]	[2]
(ii)	V = geometric(al) / <i>cis-trans</i> / <i>E-Z</i> T = optical	[1] [1]	[2]
			[15]

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1 (a)	name of element	nucleon number	atomic number	number of protons	number of neutrons	number of electrons	overall charge		
	boron	10	5	5	5	5	0	[1]	
	nitrogen	15	7	7	8	10	−3	[1]	
	lead	208	82	82	126	80	+2	[1]	
	lithium	6	3	3	3	2	+1	[1]	[4]
(b) (i)	Group 17/VII/7								
	AND								
	big (owtte) increase/big difference/big gap/big jump/jump in increase/jump in difference after 7th IE							[1]	[1]
(ii)	increases across period due to increasing attraction (of nucleus for electrons)							[1]	
	due to increasing nuclear charge/atomic/proton number AND constant/similar shielding/ same (outer) shell/energy level							[1]	[2]
(iii)	1s ² 2s ² 2p ⁶ 3s ² 3p ⁴							[1]	[1]
(c) (i)	(100 – 99.76 – 0.04=) 0.2							[1]	[1]
(ii)	$\frac{0.2x + (99.76 \times 16) + (0.04 \times 17)}{100} = 16.0044$							[1]	
	x = 18							[1]	[2]
								[Total 11]	

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Question	Answer	Mark	Total
2 (a) (i)	enthalpy / energy / heat change when one mole of <u>gaseous atoms</u> is produced from the element in its standard state under standard conditions	[1] [1] [1]	 [3]
(ii)	fluorine and chlorine are gases / bromine liquid and iodine solid OR as ΔH_{at} for bromine / iodine also includes changes of state	[1]	[1]
(iii)	$(\frac{1}{2}\text{Cl}_2 + \frac{1}{2}\text{I}_2 \rightarrow \text{ICl})$ $\Delta H_f = (\frac{1}{2}E(\text{Cl}_2) + \frac{1}{2}E(\text{I}_2)) - E(\text{ICl})$ OR $E(\text{ICl}) = (151/2) + (242/2) + 24$ $E(\text{ICl}) = (+) 220.5/221$	[1] [1]	 [2]
(b) (i)	stronger / more / greater id-id / London / dispersion forces due to increasing numbers of electrons	[1] [1]	 [2]
(ii)	(intermolecular forces in HF are) hydrogen bonds (which are) stronger (than vdW) / more energy needed to separate molecules OR HF much more polar / F much more electronegative Intermolecular forces in HF stronger (than in HCl, HBr, HI)	[1] [1] [1] [1]	 [2]
(c) (i)	P = iodine / I_2 / I ; Q = chlorine / Cl_2 / Cl	[1]	[1]
(ii)	weaker H– P than H– Q bond ORA / easier / less energy to break H– P than H– Q ORA due to greater distance / shielding of nucleus from bond pair ORA	[1] [1]	 [2]

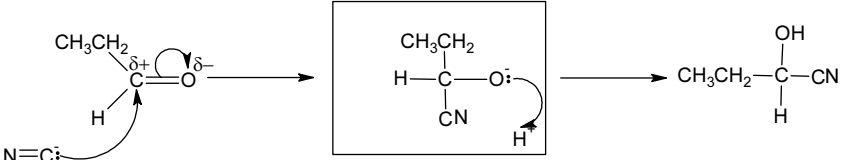
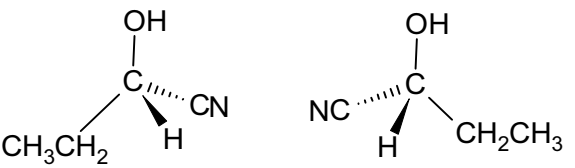
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(iii)	2HP (or 2HI) $\rightarrow$ (or $\rightleftharpoons$) $\text{H}_2 + \text{P}_2$ (or I_2)	[1]	[1]
(iv)	$\text{Ag}^+(\text{aq}) + \text{Q}^-(\text{aq})$ (or Cl^-) $\rightarrow \text{AgQ}(\text{s})$ (or $\text{AgCl}(\text{s})$)	[1]	[2]
	$\text{AgQ}(\text{s})/\text{AgCl}(\text{s}) + 2\text{NH}_3(\text{aq}) \rightarrow \text{Ag}(\text{NH}_3)_2^+(\text{aq}) + \text{Q}^-(\text{aq})/\text{Cl}^-(\text{aq})$	[1]	
(d) (i)	no of Cl increases <u>by one</u> each time / matches group number	[1]	[2]
	due to increasing number of valence/outer(most/shell) electrons / oxidation number / valency (of Mg , Al , Si)	[1]	
(ii)	MgCl_2 (+aq) $\rightarrow \text{Mg}^{2+} + 2\text{Cl}^-$	[1]	[3]
	$\text{AlCl}_3 + 6\text{H}_2\text{O} \rightarrow \text{Al}(\text{H}_2\text{O})_6^{3+} + 3\text{Cl}^-$ / $\text{Al}(\text{H}_2\text{O})_5(\text{OH})^{2+} + \text{H}^+ + 3\text{Cl}^-$	[1]	
	$\text{SiCl}_4 + 2\text{H}_2\text{O} \rightarrow \text{SiO}_2 + 4\text{H}^+ + 4\text{Cl}^-$	[1]	
		[Total 21]	
3 (a)	$\text{Cr}_2\text{O}_7^{2-} + 8\text{H}^+ + 3\text{H}_2\text{C}_2\text{O}_4 \rightarrow 2\text{Cr}^{3+} + 6\text{CO}_2 + 7\text{H}_2\text{O}$ M1 = species M2 = balancing	[1] [1]	[2]
(b) (i)	$(0.02 \times 32.0/1000 =) 6.40 \times 10^{-4}$	[1]	[1]
(ii)	$(6.4 \times 10^{-4} \times 3 =)1.92 \times 10^{-3}$	[1]	[1]
(iii)	$(0.242/1.92 \times 10^{-3} =) 126(.0)$	[1]	[1]
(iv)	$(126 - 90 = 36; 36/18 = 2 \text{ hence}) x = 2$	[1]	[1]
		[Total 6]	

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Question	Answer	Mark	Total
4 (a)	CH ₃ CH ₂ CH ₂ COOH	[1]	
	(CH ₃) ₂ CHCOOH / CH ₃ CH(CH ₃)COOH	[1]	[2]
(b) (i)	Two from 1. CH ₃ CH ₂ COOCH ₃ 2. CH ₃ COOCH ₂ CH ₃ 3. HCOOCH ₂ CH ₂ CH ₃	[1] [1]	[2]
(ii)	correct acid + alcohol for either ester 1. methanol + propanoic acid 2. ethanol + ethanoic acid 3. propan-1-ol + methanoic acid	[1]	
	(conc)H ₂ SO ₄ / (conc)H ₃ PO ₄ AND heat / warm / reflux	[1]	[2]
(c)	Peak at 1710–1750 (for ester) due to C(=)O Peak at 1500–1680 (for X) due to C(=)C / alkene Peak at 3200–3650 (for X) due to (alcohol) O(–)H	[1] [1] [1]	[3]
		[Total 9]	
5 (a) (i)	acidified / H ⁺ AND potassium / sodium dichromate		
		[1]	[1]
(ii)	distillation (rather than reflux)	[1]	
	(ensures aldehyde escapes) to avoid further oxidation / to avoid forming acid / as reflux causes further oxidation	[1]	[2]

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Question	Answer	Mark	Total
(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]	[2]
(c) (i)	 M1 = lone pair on C of CN^- AND curly arrow from lone pair to carbonyl carbon M2 = dipole on $\text{C}=\text{O}$ AND curly arrow to O from = M3 = intermediate with negative charge M4 = lone pair and curly arrow to H^+	[1] [1] [1] [1]	[4]
(ii)		[1+1]	[2]

Page 7	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark	Total
(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]	[2]
		[Total 13]	

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1 (a) (i)	$\text{Fe} + \text{H}_2\text{SO}_4 \rightarrow \text{FeSO}_4 + \text{H}_2$	[1]	[1]
(ii)	$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{Fe}^{2+} \rightarrow 2\text{Cr}^{3+} + 6\text{Fe}^{3+} + 7\text{H}_2\text{O}$	[1]	[1]
(iii)	$(0.025 \times 32.0/1000 =) 8 \times 10^{-4}$	[1]	[1]
(iv)	$(8 \times 10^{-4} \times 6 =) 4.8 \times 10^{-3}$	[1]	[1]
(v)	$(4.8 \times 10^{-3} \times 250/25.0 =) 4.8 \times 10^{-2}$	[1]	[1]
(vi)	$(4.8 \times 10^{-2} \times 55.8 =) 2.68/2.678$	[1]	[1]
(vii)	$(2.68/3.35 =) 80\%$	[1]	[1]
(b) (i)	covalent small(er) difference in electronegativity between Fe and Cl (than between Al and Cl)	[1] [1]	[2]
(ii)	$\text{FeCl}_3 + 6\text{H}_2\text{O} \rightarrow [\text{Fe}(\text{H}_2\text{O})_6]^{3+} 3\text{Cl}^-$ OR $\text{FeCl}_3 + 6\text{H}_2\text{O} \rightarrow [\text{Fe}(\text{H}_2\text{O})_6\text{OH}]^{2+} + \text{H}^+ + 3\text{Cl}^-$	[1]	[1]
			[10]
2 (a)	$\text{NH}_3 + \text{HNO}_3 \rightarrow \text{NH}_4\text{NO}_3$	[1]	[1]
(b) (i)	line from origin AND below left-hand end of original with peak to right of and lower than original crosses original once AND above right-hand end of original AND above energy axis	[1] [1]	[2]
(ii)	(curves show) more molecules with $E > E_a$ (at higher T) so greater frequency of successful (owtte) collisions / more successful (owtte) collisions per unit time	[1] [1]	[2]
(iii)	catalysed E_a shown to left of original on horizontal axis so more molecules with $E > E_a$ (in presence of catalyst)	[1] [1]	[2]

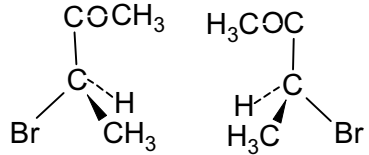
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(iv)	production of ammonia is <u>exothermic</u> / (forward) reaction <u>exothermic</u> position of eqm would move to left/reverse/reduce yield (at higher T)	[1] [1]	[2]
(c)	$4\text{NH}_3 + 5\text{O}_2 \rightarrow 4\text{NO} + 6\text{H}_2\text{O}$ N changes from –3 to +2 (so oxidation) O changes from 0 to –2 (so reduction)	[1] [1] [1]	[3]
(d) (i)	$ \begin{array}{c} \text{H} \quad (+) \\ \bullet_x \\ \text{H} \times \text{N} : \text{H} \\ \bullet_x \\ \text{H} \end{array} $	[1+1]	[2]
(ii)	shape = tetrahedral angle = 109°–109.5°	[1] [1]	[2]
(e)	eutrophication / algal bloom / stimulates growth of algae (bacteria) use up oxygen when decomposing the plants / algae block light for plants so less oxygen produced aquatic life / fish die (due to lack of oxygen)	[1] [1] [1] [1]	[max 3]
			[19]
3 (a) (i)	vaporise / boil / turn to gas	[1]	[1]
(ii)	increasing molecular size / no of carbon atoms per molecule / length of carbon chain	[1]	[1]
(iii)	increasing b.pt / decreasing volatility increasing viscosity increasing density increasing depth of colour decreasing flammability / decreasing 'cleanliness' of flame	[1] [1]	[2]
(b) (i)	$\text{C}_{12}\text{H}_{26} \rightarrow 2\text{C}_2\text{H}_4 + \text{C}_8\text{H}_{18}$	[1]	[1]

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(ii)	ethene use = <u>making</u> polythene / plastic / polymers feature of ethene = double bond / unsaturated octane / alkane use = fuel / petrol feature of octane / alkane = flammability / releases energy when burned / combusted	[1] [1] [1] [1]	[4]
(c) (i)	(produced by) reaction of (atmospheric) oxygen and nitrogen due to high temperature / engine provides energy / combustion provides energy	[1] [1]	[2]
(ii)	$2\text{NO} + 2\text{CO} \rightarrow \text{N}_2 + 2\text{CO}_2$ / $\text{NO} + \text{CO} \rightarrow \frac{1}{2}\text{N}_2 + \text{CO}_2$	[1]	[1]
(iii)	$\text{NO} + \frac{1}{2}\text{O}_2 \rightarrow \text{NO}_2$ $\text{NO}_2 + \text{SO}_2 \rightarrow \text{SO}_3 + \text{NO}$ $\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$ / $2\text{H}^+ + \text{SO}_4^{2-}$ / $\text{H}^+ + \text{HSO}_4^-$	[1] [1] [1]	[3]
(iv)	lowers pH of rivers / lakes / kills fish leaches (toxic) aluminium from soil (into rivers / lakes) leaches away soil nutrients damage to buildings / statues / trees / plants / crops ocean acidification / damage to coral	[1] [1] [1] [1] [1]	[max 2]
			[17]
4 (a)	3-hydroxybutan(-2-)one	[1]	[1]
(b)	H_2 / $\text{Cr}_2\text{O}_7^{2-}$ or names heat / reflux / warm	[1] [1]	[2]
(c) (i)	absorption at 1670–1740 C (=) O absorption at 2850–3000 C (-) H absorption at 3200–3650 O (-) H	[1] [1] [1]	[3]

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(ii)	no absorption at 3200–3650 O-H disappears / no O-H bond in diacetyl	[1] [1]	[2]
(d) (i)	CH ₃ COCH(=)CH ₂	[1]	[1]
(ii)	one of the double-bonded C atoms / first C has 2H atoms attached ora so no cis-trans / <i>E-Z</i> / geometric(al) isomerism possible OR no chiral C so mirror images superimposable / molecule not asymmetric	[1] [1]	[2]
(iii)	asymmetric / chiral C atom / carbon with four different groups / atoms attached	[1]	[1]
(iv)		[1+1]	[2]
			[14]