

**GCE**

**Chemistry B (Salters)**

Unit **F334**: Chemistry of Materials

Advanced GCE

**Mark Scheme for June 2016**

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All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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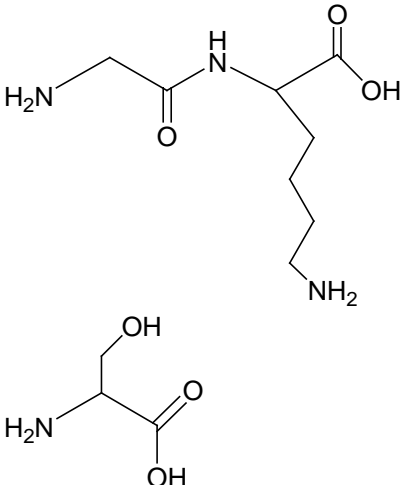
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## Annotations

Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Transcription error
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Error in number of significant figures
	Correct response
	Wrong physics or equation

## Abbreviations, annotations and conventions

<b>Annotation</b>	<b>Meaning</b>
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
<b>IGNORE</b>	Statements which are irrelevant
<b>ALLOW</b>	Answers that can be accepted
( )	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
<b>ECF</b>	Error carried forward
<b>AW</b>	Alternative wording
<b>ORA</b>	Or reverse argument

Question		Expected Answers	Marks	Additional Guidance
1	a	secondary structure: the folding of the chains <b>OR</b> (forms) helices or sheets ✓ tertiary structure: further folding <b>OR</b> (final) 3D structure ✓	2	
	b	a hole / cleft / crevice / specific shape (in the enzyme structure) AW ✓  substrate/ protein binds/fits/bonds ✓ reaction/ hydrolysis occurs / substrate is broken down / conversion into products ✓	3	<b>ALLOW</b> part of protein tertiary structure <b>ALLOW</b> shape in enzyme which fits substrate  <b>ALLOW</b> catalyse reaction between enzyme and substrate
	c	 <p>some hydrolysis at one or more amide links showing –COOH and –NH<sub>2</sub> on two different molecules ✓ idea of correct (right-hand) amide link <b>only</b> being hydrolysed ✓ completely correct ✓</p>	3	accept any unambiguous structures
	d	<i>two marking points from:</i> trypsin is selective / specific (with hydrolysis) AW ✓ bromate / bromine / Br is toxic / forms a toxic product / dangerous or harmful to humans ✓ enzymes give better atom economy ✓	2	<b>IGNORE</b> any reference to 'altering active site' <b>NOT</b> cheaper <b>ORA</b> Trypsin and/or products are non-toxic

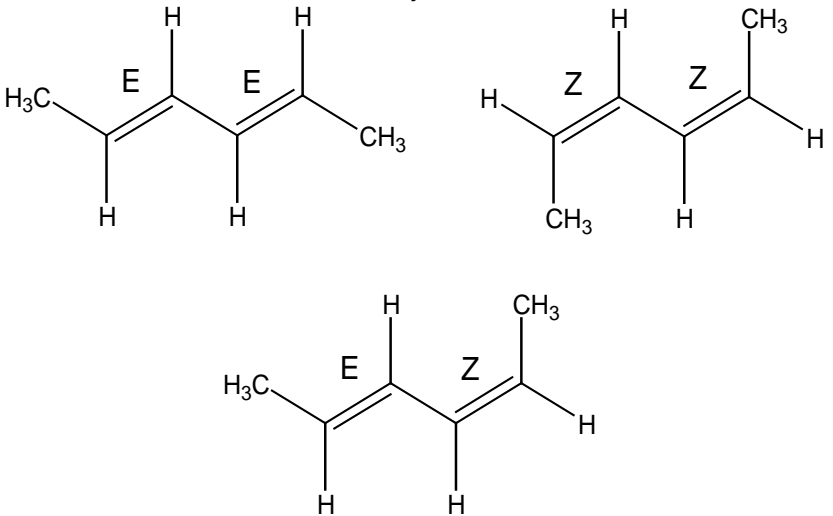
Question		Expected Answers	Marks	Additional Guidance
e	i	<p><b>first part of graph</b></p> <p>first order for substrate – related to shape (e.g. ‘graph shows proportional’ / ‘linear’/ ‘rate doubles as conc. doubles’/ ‘constant positive gradient’ AW) ✓  rds is equation 1 / substrate is in rds ✓</p> <p><b>second part of graph</b>  zero order for substrate ✓  rds is equation 2 (or no longer equation 1) / substrate no longer in rds ✓  all active sites (on enzyme) full/ saturated ✓</p>	5	<p><b>QWC</b> – to score first mark, the statement of first order must be related to the shape/attributes of the graph  may write reasoning on graph but just saying 1<sup>st</sup> order is insufficient for mark</p> <p><b>NOT</b> just ‘straight’</p>
e	ii	<p>straight line (parallel to x-axis) at rate = 0 ✓</p> <p><u>active site</u> is destroyed / changes shape ✓</p>	2	<p>may draw a diagram  <b>ALLOW</b> line along the x-axis  <b>IGNORE</b> denatured</p>
<b>Total</b>			<b>17</b>	

Question			Expected Answers	Marks	Additional Guidance
2	a	i	$E^\ominus$ / half-cell potential of $\text{Cr}^{3+}/\text{Cr}^{2+}$ / solution <b>A</b> is more negative (than $E^\ominus$ of $\text{Fe}^{3+}/\text{Fe}^{2+}$ ) <b>ORA</b> ✓  so $\text{Cr}^{3+}/\text{Cr}^{2+}$ will be the negative electrode / cathode / lose electrons <b>ORA</b> <b>AND</b> $\text{Cr}^{3+}/\text{Cr}^{2+}$ / solution <b>A</b> goes into tank 2 <b>and/or</b> $\text{Fe}^{3+}/\text{Fe}^{2+}$ / solution <b>B</b> into tank 1 ✓	2	<b>IGNORE</b> comments about reducing and oxidising agents <b>NOT</b> $E^\ominus_{\text{cell}}$
	a	ii	$\text{Cr}^{2+} + \text{Fe}^{3+} \rightarrow \text{Cr}^{3+} + \text{Fe}^{2+}$ ✓	1	
	a	iii	prevent corrosion/rusting/oxidation of iron/steel ✓ iron/steel would act as an electrode / react with solutions / electrolytes / forms ions ✓  polymer / plastic / paint	3	<b>If LIST then use 1<sup>st</sup> substance ONLY</b> <b>NOT</b> zinc/galvanising or grease <b>ALLOW</b> any named polymer <b>ALLOW</b> ceramic
	a	iv	allow charge flow / transfer AW <b>or</b> act as a salt bridge <b>or</b> allows ion flow ✓	1	<b>IGNORE</b> prevent mixing of the solutions <b>CON</b> electron flow <b>NOT</b> flow of current
	a	v	carbon / graphite / platinum ✓	1	
	b		-0.26 ✓	1	correct sign must be present

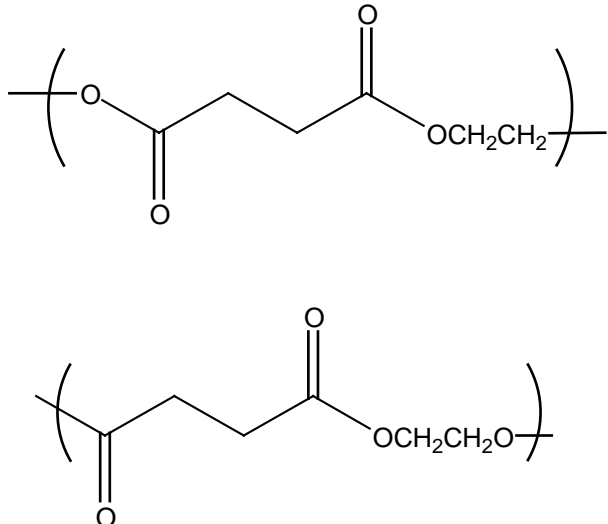
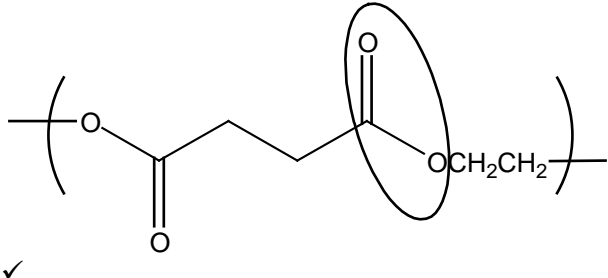
Question		Expected Answers	Marks	Additional Guidance
	<b>c</b>	<p>(red brown ppt.) is <math>\text{Fe}(\text{OH})_3</math> / iron(III) hydroxide ✓</p> <p><math>\text{Fe}^{2+}</math> ions will have been <u>oxidised</u> to <math>\text{Fe}^{3+}</math> ions by <u>oxygen</u> (from the air) ✓</p> <p><math>4\text{Fe}^{2+} + \text{O}_2 + 2\text{H}_2\text{O} \rightarrow 4\text{Fe}^{3+} + 4\text{OH}^-</math>  <b>OR</b> <math>2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^- \rightarrow 4\text{OH}^-</math> AND <math>\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^-</math> ✓</p> <p><math>\text{Fe}^{3+}(\text{aq}) + 3\text{OH}^-(\text{aq}) \rightarrow \text{Fe}(\text{OH})_3(\text{s})</math> ✓</p> <p>state symbols correct for species in correct precipitation equation ✓</p>	<b>5</b>	<p><b>Allow</b> mark if precipitation equation has <math>\text{Fe}(\text{OH})_3(\text{s})</math> as product  <b>ALLOW</b> red ppt.  <b>CON is</b> <math>\text{Fe}(\text{OH})_2</math> is formed first</p> <p>oxygen may be seen in the equation</p>
<b>Total</b>			<b>14</b>	



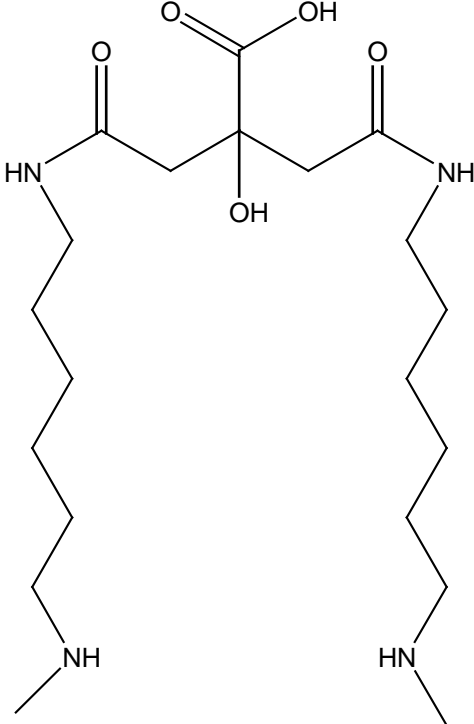
Question		Expected Answers	Marks	Additional Guidance
3	a	moles of $C_6H_{10}$ in 100 g = <b>100/82.(0)</b> = (1.22) ✓ bromine number = $100/82.0 \times 2 \times 159.8 = 390$ ✓	2	ECF <b>ALLOW</b> $M_r$ for bromine = 160 <b>IGNORE</b> g units with answer
	b	<b>i</b> <b>Method 1 MOLES</b> moles of $BrO_3^-$ = 0.005 AND moles of $Br^-$ = 0.0167 ✓ to be in excess moles of $BrO_3^-$ has to be > (0.0167/5 =) 0.00334 mol $dm^{-3}$ ✓ <b>Method 2 CONCENTRATIONS</b> $[BrO_3^-] = 0.0250$ AND $[Br^-] = 0.0835$ ✓ to be in excess $[BrO_3^-]$ has to be > (0.0835/5 =) 0.0167 mol $dm^{-3}$ ✓	2	must have words as well as numbers for 2 <sup>nd</sup> mark
	b	<b>ii</b> moles of $Br^-$ (forming $Br_2$ ) = <b>0.167</b> x 100/1000 or <b>(0.0167)</b> ✓ moles of $Br_2$ reacted with 10 g sample = $0.0167 \times 3/5$ ✓ x <b>82/200</b> ✓ = (0.00411) mass of $Br_2$ reacted with 10 g sample = $0.0167 \times 3/5 \times 82/200$ x <b>159.8</b> = (0.656 g) ✓ bromine number = $0.0167 \times 3/5 \times 82/200 \times 159.8 \times 10 =$ 6.56 = <b>7</b> ✓	5	<b>Alternative method:</b> moles of $Br_2$ formed in reaction in 200 $cm^3$ = $0.0167 \times 3/5 = (0.01002)$ ✓ $[Br_2] = 0.0167 \times 3/5 \times 5 = (0.501)$ ✓ moles of $Br_2$ used in adding to sample = $0.501 \times$ <b>82/1000</b> = 0.0411 ✓ mass of $Br_2$ added to 10.0 g sample = $0.0411 \times$ <b>159.8</b> = (6.56) g ✓ bromine number = <b>7</b> ✓ ECF throughout calculation <b>IGNORE</b> g units with answer
	c	<b>i</b> restrictive rotation about C=C bonds ✓ two different atoms/groups attached to both carbon atoms of the C=C bond ✓	2	<b>ALLOW</b> C=C bonds cannot rotate <b>ALLOW</b> 'lack of free rotation' <b>NOT</b> just 'double bonds' <b>IGNORE</b> functional

Question		Expected Answers	Marks	Additional Guidance
c	ii	<p>1 mark for each correct isomer provided no more than 3 ✓✓✓</p> <p>1 mark for labels drawn correctly on the 3 correct structures ✓</p> 	4	<p>extra structures are each CON to one isomer mark already scored (watch out for E-Z and Z-E which is a CON)</p> <p><b>ALLOW</b> skeletal structures</p>
d		<p>atoms/transition metals (on surface) can use <u>d</u> (and s) electrons / subshell / orbital(s) ✓</p> <p>to form (weak) bonds to/interactions with reactants ✓</p> <p>providing a route of lower <math>E_a</math> ✓</p>	3	<p><b>IGNORE</b> orbital numbers</p> <p><b>ALLOW</b> chemisorption BUT NOT adsorption</p>
e	i	<p>bromine / <math>\text{Br}_2</math> ✓</p> <p>colorimetry <b>OR</b> titration ✓</p> <p>bromine (solution) is yellow/orange/(red) brown</p> <p><b>OR</b></p> <p>bromine decolourised in titration (phenol and with methyl orange) ✓</p>	3	<p><b>Only 2<sup>nd</sup> mark is independent</b></p> <p><b>ALLOW</b> titration of bromine with a solution of alkene with known bromine number</p> <p><b>DO NOT ALLOW</b> titrate with alkali, method not appropriate</p> <p><b>ALLOW</b> bromine is the only coloured substance / reactants are colourless bromine coloured</p>

Question		Expected Answers	Marks	Additional Guidance
e	ii	(Rate =) $k \times [\text{BrO}_3^-] \times [\text{Br}^-] \times [\text{H}^+]^2$	3	<b>ALLOW</b> capital K one order incorrect gets 1 mark of the last two marks <b>ALLOW</b> if signs missing on ions but orders are correct <b>IGNORE</b> bracket type
e	iii	some bromine escapes / bromine is volatile ✓ slower/smaller value / rate (appears to) decreases ✓ since rate measured as $[\text{Br}_2] \text{ s}^{-1}$ ✓	3	<b>IGNORE</b> discussion of effect of temperature increase
<b>Total</b>			<b>27</b>	

Question			Expected Answers	Marks	Additional Guidance
4	a	i	either of the following structures ✓ 	1	<b>ALLOW</b> any correct structure using any skeletal and/or structural formulae conventions  <b>ALLOW</b> without brackets BUT MUST have linking bonds
	a	ii	<u>polyester</u> ✓	1	<b>IGNORE</b> condensation
	a	iii		1	<b>DO NOT ALLOW</b> if C atoms are circled

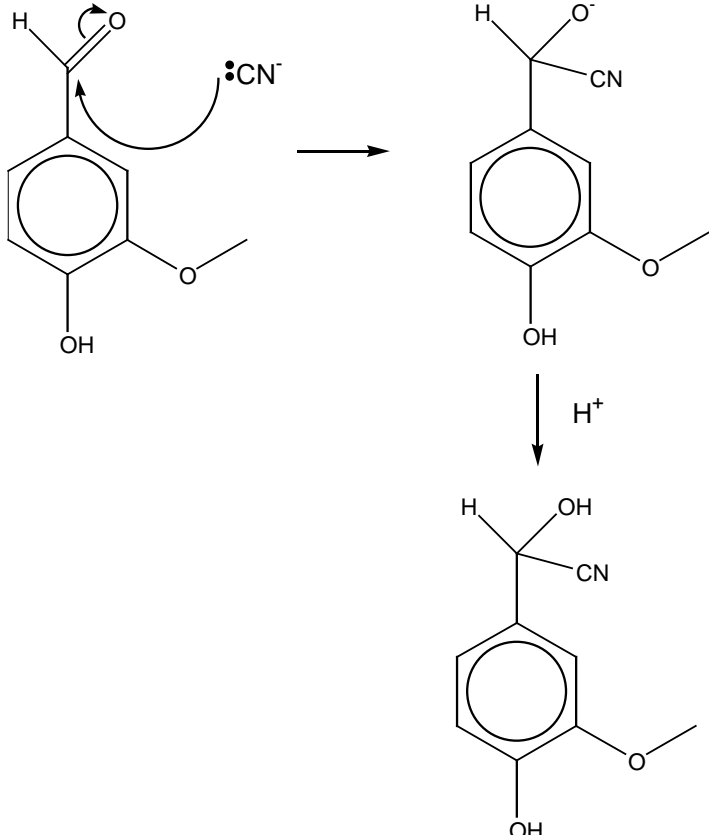
Question		Expected Answers	Marks	Additional Guidance
	<b>b</b> <b>i</b>	<p><b>imb/fs in polyesters:</b> instantaneous (dipole)-induced dipole / Van-der-Waals AND permanent (dipole)-permanent dipole ✓</p> <p><b>imb/fs in polyamides:</b> instantaneous (dipole)-induced dipole AND permanent (dipole)-permanent dipole AND hydrogen bonds ✓</p> <p>a <u>hydrogen</u> bond is stronger than the other correct imb/fs ✓</p> <p>stronger bonds between chains/molecules (mean stronger fibres) ✓</p>	<b>4</b>	<p><b>DO NOT ALLOW</b> abbreviations nor shortened names (e.g. permanent dipole bonds for bond types) UNLESS the full names have been used first</p> <p><b>ALLOW</b> abbreviations if full names given once</p> <p><b>ALLOW</b> hydrogen bonds are the strongest</p> <p><b>ALLOW</b> more energy needed to break bonds between chains</p>
	<b>b</b> <b>ii</b>	<p>stretching polymer AW ✓</p> <p>causes chains to be aligned/lined up / makes polymer more crystalline ✓</p> <p>chains are closer together so imb/fs stronger ✓</p>	<b>3</b>	<p><b>ALLOW</b> 'pulled'</p> <p><b>DO NOT ALLOW</b> stretching polymer chains</p> <p><b>IGNORE</b> cooling</p> <p><b>NOT</b> heating</p> <p><b>NOT</b> more imb/fs</p> <p><b>IGNORE</b> any references to 'energy'</p>
	<b>c</b> <b>i</b>	1,6-diaminohexane ✓	<b>1</b>	<p><b>ALLOW</b> hexane-1,6-diamine</p> <p><b>IGNORE</b> commas, dashes and gaps.</p>

Question		Expected Answers	Marks	Additional Guidance
c	ii	 <p>an amide group correct ✓ structure all correct ✓</p>	2	<p><b>ALLOW</b> <math>\text{-NH(CH}_2\text{)}_6\text{NH}_2</math> <i>i.e.</i> <math>\text{NH}_2</math> at end of chain</p> <p><b>ALLOW</b> <math>\text{-NH-}</math></p> <p><b>ALLOW</b> correct structure formed by use of central <math>\text{-COOH}</math> (one of the side chains will lack a <math>\text{-CH}_2\text{-}</math> before the amide group)</p>

Question			Expected Answers	Marks	Additional Guidance
	c	iii	(polymer) chains / molecules <b>OR</b> polymers have groups (unspecified or correctly specified)  can form hydrogen bonds with water ✓	1	<b>ANY OF</b> secondary amide, carboxylic acids, hydroxyl and carboxyl <b>NOT</b> NH <sub>2</sub>
	c	iv	<b>two</b> from the following:  is it safe? does it work? AW is it better than other substances? AW are they stable (in the human environment)? no / any side effects? ✓ ✓	1	<b>NOT</b> safe dose  <b>IGNORE</b> is it toxic?
4	c	v	N atom has a <u>lone pair</u> (of electrons) (May be shown on formula) ✓ can accept a proton/H <sup>+</sup> ✓	2	<b>DO NOT ALLOW</b> H / H atom / H ion <b>ALLOW</b> accepts protons mark separately
<b>Total</b>				<b>17</b>	

Question			Expected Answers	Marks	Additional Guidance
5	a	i	aldehyde/ carbonyl ether / methoxy phenol / hydroxyl  ALL three correct ✓✓ TWO correct out of 2 or 3 answers ✓	2	any answer with 4 groups listed deduct 1 mark more than 4 groups award no marks <b>DO NOT ALLOW</b> hydroxide / hydroxy <b>ALLOW</b> phenolic hydroxy
	a	ii	sulfuric acid <b>AND</b> potassium/sodium dichromate(VI) ✓	1	<b>ALLOW</b> without oxidation state, but if given must be correct <b>ALLOW</b> 'acidified (potassium) dichromate' <b>ALLOW</b> sulfuric acid as the only named acid <b>IGNORE</b> concentration of acid
	b	i	1705 indicates C=O in ketone /or carboxylic acid thus apocynin ✓  3310 indicates OH in <b>phenol</b> ✓  3010 indicates CH in arene/benzene ring <b>AND</b> 2930 indicates CH in alkane ✓	3	<b>ALLOW</b> since NOT 1720-1700 it is not an aldehyde so must be apocynin  <b>IGNORE</b> alcohol  <b>IGNORE</b> alkene
	b	ii	1. compare the M <sup>+</sup> / molecular (ion) peaks (AW) ✓  molecular ion peak of apocynin will be at a larger <i>m/z</i> by 14 <b>or</b> molecular ion peak's <i>m/z</i> is in vanillin at 152, in apocynin at 166 ✓ <b>2.</b> look for peak at <i>m/z</i> 43 or 29 ✓ due to COCH <sub>3</sub> <sup>+</sup> / COCH <sub>3</sub> group from apocynin or due to CHO <sup>+</sup> /CHO from vanillin ✓	2 from	Comparison may be assumed by stating the two values <b>ALLOW</b> peak in vanillin at molecular ion peak's <i>m/z</i> -1 (loss of aldehyde H) indicates vanillin <b>IGNORE</b> loss of methyl group / peak at <i>m/z</i> =15
	b	iii	dissolve in a minimum amount of hot/warm <u>water</u> AW ✓ <b>QWC mark</b> leave to crystallise / crystals to form and filter ✓  wash crystals with (a little cold) water / solvent and dry ✓	3	<b>ALLOW</b> formation of saturated solution spelling of (re)crystallise / recrystallisation / crystals <b>MUST BE CORRECT at least once</b> <b>ALLOW</b> crystallisation / crystallize / crystallization



Question	Expected Answers	Marks	Additional Guidance
c	 <p>2 curly arrows (1 from lone pair on C of CN) AND bond polarity correct on at least one atom of C=O (<math>\delta^+C=O\delta^-</math>) ✓  correct formula for cyanide including lone pair on C and -ve charge on CN ✓  intermediate correct ✓  addition of H<sup>+</sup> AND final product correct ✓</p>	4	<p><b>IGNORE</b> any curly arrows and lone pairs involving formation of the -OH group</p> <p><b>IGNORE</b> curly arrow from / to H<sup>+</sup></p>
<b>Total</b>		<b>15</b>	

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