

## Mark schemes

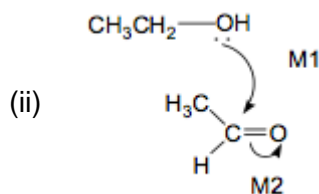
1

(a) (i) Nucleophilic addition

*Any extra loses the mark*

*Allow minor spelling errors e.g. nucleophyllic*

1



*M1 for arrow from lone pair on oxygen in ethanol to C of  $\text{C=O}$  (or to space half way between O and C)*

*M2 for arrow from  $\text{C=O}$  bond to oxygen in ethanal*

*Do not allow M2 as first step without nucleophilic attack, but can allow M1 for attack on  $\text{C}^+$  produced*

*+ rather than  $\delta^+$  on  $\text{C=O}$  loses M2*

*Ignore any further steps*

*Mark independently*

1

1

(b) (i) Equal mixture of enantiomers/optical isomers OWTTE

1

(ii) (Non-superimposable) mirror images

*Ignore rotates light in opposite directions*

*Ignore stereoisomers*

1

(c) (i) Ethanal 0.33

1

Ethanol 4.16

*Allow 4.2 for ethanol*

1

$$(ii) \quad K_c = \frac{[acetal][H_2O]}{[CH_3CHO][CH_3CH_2OH]^2} \text{ or with names}$$

$$\frac{(0.37/0.31)(0.65/0.31)}{(0.58/0.31)(3.76/0.31)^2} \quad \text{OR} \quad \frac{(0.37)(0.65)}{(0.58)(3.76)^2} \times 0.31$$

Ignore slips in acetal structure or formula  $C_6H_{14}O_2$

If  $K_c$  wrong, allow M4 only for units conseq to their  $K_c$

If volume omitted (gives  $2.93 \times 10^{-2}$ ) may only score M1 and M4

If volume used =  $310 \text{ cm}^3$  allow M2 then award M3 for  $9.08 - 9.23$  only and M4 for  $\text{mol}^{-1} \text{ cm}^3$  only

Treat error in converting  $310 \text{ cm}^3$  to  $\text{dm}^3$  as AE

M1  
M2

$$9.1 \times 10^{-3}$$

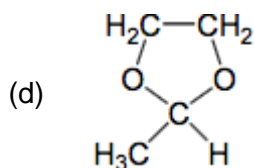
Allow range  $9.08 \times 10^{-3} - 9.23 \times 10^{-3}$

M3

$$\text{mol}^{-1}\text{dm}^3$$

Not  $\text{moles}^{-1}\text{dm}^3$

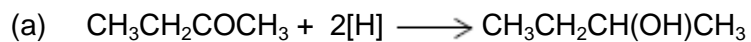
M4



1

[12]

2



1

- (b) This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.

All stages are covered and the explanation of each stage is generally correct and virtually complete.

Answer is communicated coherently and shows a logical progression from stage 1 to stage 2 then stage 3.

**Level 3**  
**5 – 6 marks**

All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete.

Answer is mainly coherent and shows progression from stage 1 to stage 3.

**Level 2**  
**3 – 4 marks**

Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, OR only one stage is covered but the explanation is generally correct and virtually complete.

Answer includes isolated statements but these are not presented in a logical order or show confused reasoning.

**Level 1**  
**1 – 2 marks**

Insufficient correct chemistry to gain a mark.

**Level 0**  
**0 marks**

### **Indicative Chemistry content**

#### **Stage 1: Formation of product**

- Nucleophilic attack
- Planar carbonyl group
- H<sup>-</sup> attacks from either side (stated or drawn)

#### **Stage 2: Nature of product**

- Product of step 1 shown
- This exists in two chiral forms (stated or drawn)
- Equal amounts of each enantiomer / racemic mixture formed

#### **Stage 3: Optical activity**

- Optical isomers / enantiomers rotate the plane of polarised light equally in
- With a racemic / equal mixture the effects cancel

6

[7]

3

- (a) A mixture of liquids is heated to boiling point for a prolonged time

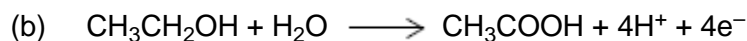
1

Vapour is formed which escapes from the liquid mixture, is changed back into liquid and returned to the liquid mixture

1

Any ethanal and ethanol that initially evaporates can then be oxidised

1



1

(c) Mixture heated in a suitable flask / container

*A labelled sketch illustrating these points scores the marks*

1

With still head containing a thermometer

1

Water cooled condenser connected to the still head and suitable cooled collecting vessel

1

Collect sample at the boiling point of ethanal

1

Cooled collection vessel necessary to reduce evaporation of ethanal

1

(d) Hydrogen bonding in ethanol and ethanoic acid or no hydrogen bonding in ethanal

1

Intermolecular forces / dipole-dipole are weaker than hydrogen bonding

1

(e) Reagent to confirm the presence of ethanal:

Add Tollens' reagent / ammoniacal silver nitrate / aqueous silver nitrate followed by 1 drop of aqueous sodium hydroxide, then enough aqueous ammonia to dissolve the precipitate formed

**OR**

Add Fehling's solution

1

Warm

*M2 and M3 can only be awarded if M1 is given correctly*

1

Result with Tollen's reagent:

Silver mirror / black precipitate

**OR**

Result with Fehling's solution:

Red precipitate / orange-red precipitate

1

Reagent to confirm the absence of ethanoic acid

Add sodium hydrogencarbonate or sodium carbonate

1

Result; no effervescence observed; hence no acid present

1

*M5 can only be awarded if M4 is given correctly*

**OR**

Reagent; add ethanol and concentrated sulfuric acid and warm

Result; no sweet smell / no oily drops on the surface of the liquid,

hence no acid present

[16]

4

B

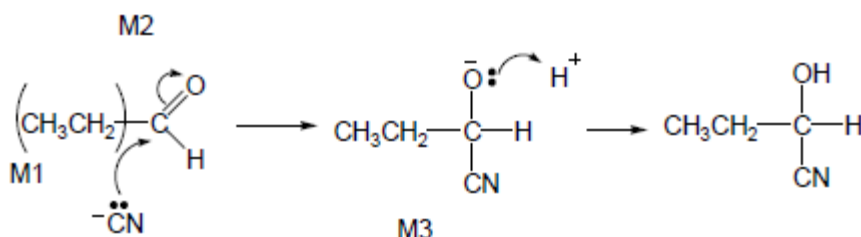
[1]

5

(a) Nucleophilic addition

1

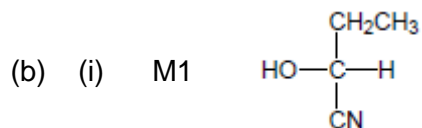
M4 for lp, arrow and H<sup>+</sup>



Allow C<sub>2</sub>H<sub>5</sub>- for CH<sub>3</sub>CH<sub>2</sub>-

- *M1 and M4 include lone pair and curly arrow.*
- *Allow: CN<sup>-</sup> but arrow must start at lone pair on C.*
- *M2 not allowed independent of M1, but allow M1 for correct attack on C<sup>+</sup>.*
- *+ rather than δ<sup>+</sup> on C=O loses M2.*
- *Penalise incorrect partial charges.*
- *M3 is for correct structure including minus sign but lone pair is part of M4.*
- *Penalise extra curly arrows in M4.*

4

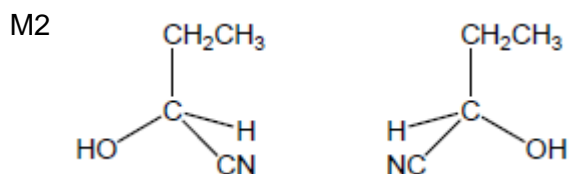


M1 for correct structure of product of part (a).

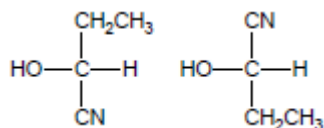
Allow C<sub>2</sub>H<sub>5</sub>- for CH<sub>3</sub>CH<sub>2</sub>-.

Penalise wrongly bonded, OH or CN or CH<sub>2</sub>CH<sub>3</sub> once only in clip.

1

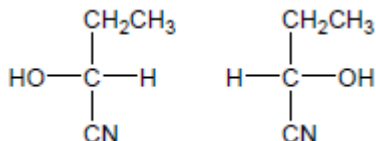


M2 cannot be gained by simply swapping two or more groups with no attempt to show a mirror image., e.g. do not allow M2 for



because these do not show the enantiomers as mirror images.

Students must show an attempt at mirror images, eg allow

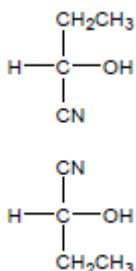


ie vertical groups same and horizontal swapped as if there was a mirror between them

No mirror need be shown

Do not penalize wedge bond when wedge comes into contact with both C & N

However these two could score M2 if placed as below as if with a "mirror" horizontally between them.



1

- (ii) M1 (Plane) polarized light  
M2 only scores following correct M1

1

M2 Rotated in opposite directions (equally) (only allow if M1 correct or close)

*Not just in different directions but allow one rotates left to the left and one to the right.*

*Not molecules rotate.*

1

(c) 2-hydroxybutane(-1-)nitrile

1

(d) Weak acid / (acid) only slightly / partially dissociated / ionised

*Ignore rate of dissociation.*

1

[CN<sup>-</sup>] very low

*Allow (very) few cyanide ions.*

*Mark independently.*

1

(e) (i)  $\text{H}_2\text{C}=\text{CH}-\text{CH}_3 + \text{NH}_3 + \frac{3}{2}\text{O}_2 \longrightarrow \text{H}_2\text{C}=\text{CH}-\text{CN} + 3\text{H}_2\text{O}$

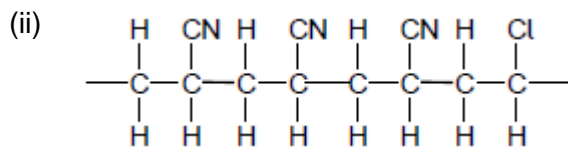
**OR**

$\text{H}_2\text{C}=\text{CH}-\text{CH}_3 + \text{NH}_3 + 3\text{O}_2 \longrightarrow \text{H}_2\text{C}=\text{CH}-\text{CN} + 3\text{H}_2\text{O}_2$

*OR doubled.*

*Allow C<sub>3</sub>H<sub>6</sub> and CH<sub>2</sub>CHCN or C<sub>3</sub>H<sub>3</sub>N on this occasion only.*

1

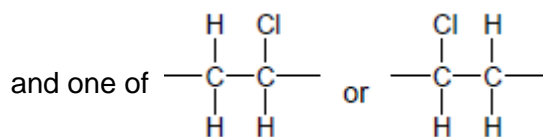
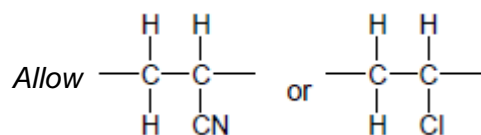
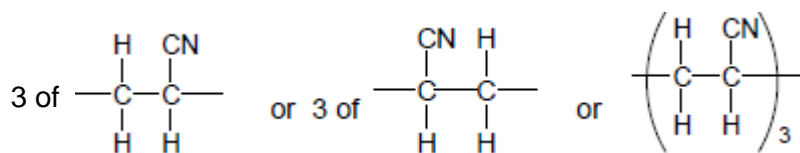


*Ignore n.*

*Must show trailing bonds.*

*Do not penalise C–NC bond here on this occasion.*

Must contain, in any order,



*Allow  $-\text{CH}_2\text{CH}(\text{CN})\text{CH}_2\text{CHCl}-$  etc.*

1

(iii) Addition (polymerization)

*Allow self-addition.*

*Do not allow additional.*

1

[15]

6

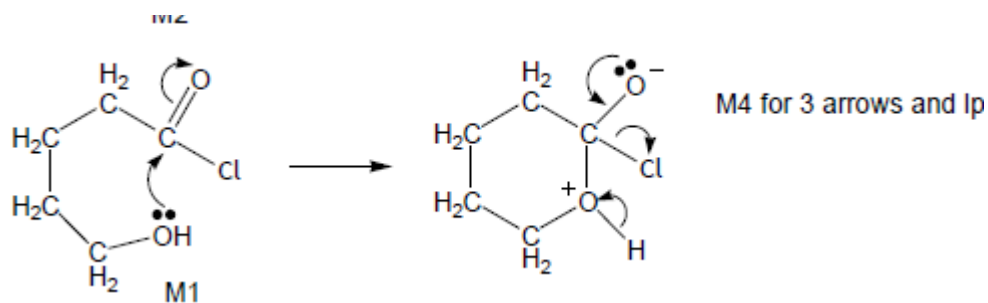
(a) (i) (nucleophilic) addition-elimination

*Not electrophilic addition-elimination*

*Ignore esterification*

1





M3 for structure

- If wrong nucleophile used or O–H broken in first step, can only score M2.
- M2 not allowed independent of M1, but allow M1 for correct attack on C+
- + rather than  $\delta+$  on C=O loses M2.
- If Cl lost with C=O breaking lose M2.
- M3 for correct structure with charges but lone pair on O is part of M4.
- Only allow M4 after correct / very close M3.
- Ignore HCl shown as a product.

4

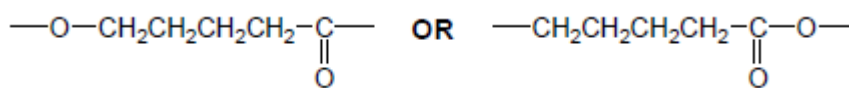
a 20-50 (ppm) or single value or range entirely within this range  
If values not specified as a or b then assume first is a.

1

b 50-90 (ppm) or single value or range entirely within this range

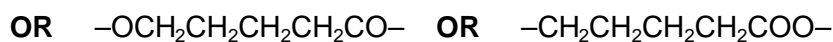
1

(ii)

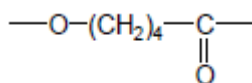


Must have trailing bonds, but ignore n.

1



Allow



but not  $\text{—C}_4\text{H}_8\text{—}$

one unit only

Condensation

1

(b)

	Tollens'	Fehling's / Benedicts	Acidified potassium dichromate
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*Penalise wrong formula for Tollens or missing acid with potassium dichromate but mark on.*

1

<b>J</b>	No reaction / no (visible) change / no silver mirror	No reaction / no (visible) change / stays blue / no red ppt	No reaction / no (visible) change / stays orange / does not turn green
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*Ignore 'clear', 'nothing'.*

*Penalise wrong starting colour for dichromate.*

1

<b>K</b>	Silver <u>mirror</u> / grey <u>ppt</u>	Red <u>ppt</u> (allow brick red or red-orange)	(orange) turns green
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1

**J** Two (peaks)

*Allow trough, peak, spike.*

1

**K** Four (peaks)

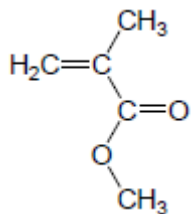
*Ignore details of splitting.*

*If values not specified as J or K then assume first is J.*

1

(c) If all the structures are unlabelled, assume that the first drawn ester is L, the second ester is M; the first drawn acid is N, the second P. The cyclic compound should be obvious.

**L**  
ester



**OR**  $\text{H}_2\text{C}=\text{C}(\text{CH}_3)\text{COOCH}_3$

**All  $\text{C}_5\text{H}_8\text{O}_2$  L to P must have  $\text{C}=\text{C}$ .**

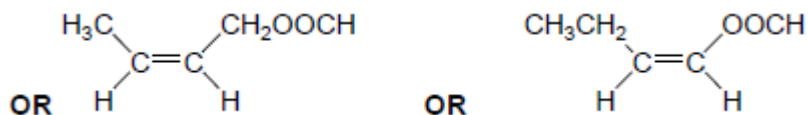
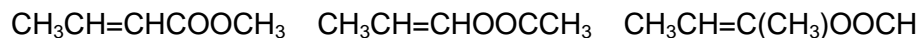
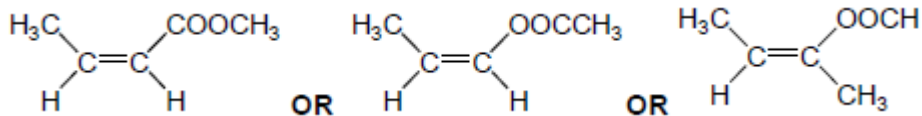
*Allow  $\text{CH}_3^-$ .*

*Allow  $-\text{CO}_2\text{CH}_3$  etc.*

*Allow  $\text{CH}_2\text{C}(\text{CH}_3)\text{COOCH}_3$ .*

1

**M**  
ester



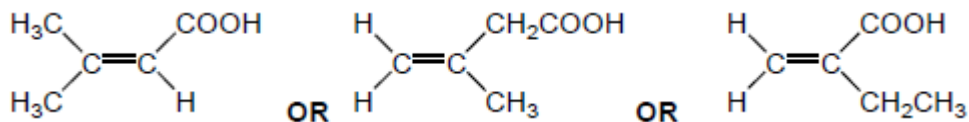
Allow either *E-Z* isomer.

Allow  $\text{CH}_3-$  or  $\text{C}_2\text{H}_5-$  but not  $\text{CH}_2\text{CH}_3-$ .

Allow  $\text{CH}_3\text{CHCHCOOCH}_3$  etc.

1

**N**  
acid

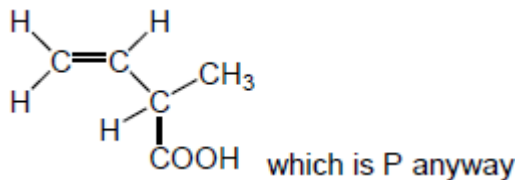


Allow  $\text{CH}_3-$  or  $\text{C}_2\text{H}_5-$  but not  $\text{CH}_2\text{CH}_3-$ .

Allow  $-\text{CO}_2\text{H}$ .

Not cyclic isomers.

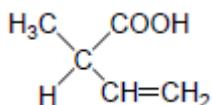
Not the optically active isomer.



Allow  $(\text{CH}_3)_2\text{CCHCOOH}$  etc.

1

**P**  
acid



Allow  $-\text{CO}_2\text{H}$ .

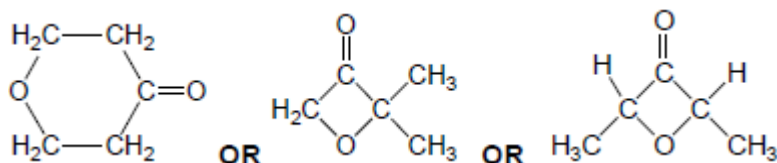


Allow  $\text{CH}_3\text{CH}(\text{CO}_2\text{H})\text{CHCH}_2$  or

$\text{CH}_3\text{CH}(\text{CO}_2\text{H})\text{C}_2\text{H}_5$ .

1

Q



Not cyclic esters.

1

[19]

7

- (a) (i) 2-hydroxypropanoic acid

**OR**

2-hydroxypropan(-1-)oic acid

*Do not penalise different or missing punctuation or extra spaces.*

*Spelling must be exact and order of letters and numbers as here.*

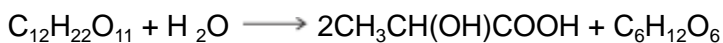
*Can ignore -1- before -oic, but penalise any other numbers here.*

1

- (ii)  $C_{12}H_{22}O_{11} + H_2O \longrightarrow 4CH_3CH(OH)COOH$

*Allow  $4C_3H_6O_3$*

**OR**

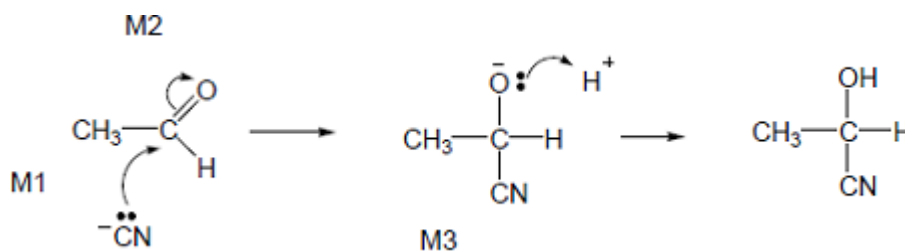


*Allow  $2C_3H_6O_3$*

1

- (b) (i) Nucleophilic addition

M4 for lp, arrow and H+



- M1 lp and minus must be on C
- M1 and M4 include lone pair and curly arrow.
- M2 not allowed independent of M1, but allow following some attempt at attack on carbonyl C
- allow M1 for correct attack on C+
- + rather than  $\delta+$  on C=O loses M2
- M3 is for correct structure including minus sign but lone pair is part of M4
- Allow arrow in M4 to H of H-CN with arrow forming cyanide ion.

5

- (ii) Equal mixture of enantiomers / (optical) isomers 1
- (iii) (Plane) polarized light 1  
*If missing no further mark.*
- (Polarised light) rotated by single enantiomer but unaffected by racemate 1  
*Both needed; not allow bend, twist etc.*
- (c) (i)  $\text{CH}_3\text{CH}(\text{OH})\text{COOH} + \text{NaOH} \rightarrow \text{CH}_3\text{CH}(\text{OH})\text{COONa} + \text{H}_2\text{O}$   
**OR**  $\text{CH}_3\text{CH}(\text{OH})\text{COOH} + \text{OH}^- \rightarrow \text{CH}_3\text{CH}(\text{OH})\text{COO}^- + \text{H}_2\text{O}$   
*Not ambiguous mol formulae for product - must show COONa or CO<sub>2</sub>Na or COO<sup>-</sup> or CO<sub>2</sub><sup>-</sup>* 1
- (ii)  $[\text{H}^+] = K_a$  **OR**  $\text{pH} = \text{p}K_a$  1  

$\text{pH} = 3.86$   
*Allow more than 2 decimal places but not fewer.* 1
- (iii) M1 buffer 1  
*Ignore acidic but penalise alkaline or basic.*

**Any two out of the three marks M2 , M3 & M4**

M2 Large lactate concentration in buffer  
**OR** sodium lactate completely ionised

M3 added acid reacts with / is removed by lactate ion or  $\text{A}^-$  or sodium lactate or salt

**OR** equation  $\text{H}^+ + \text{A}^- \rightarrow \text{HA}$

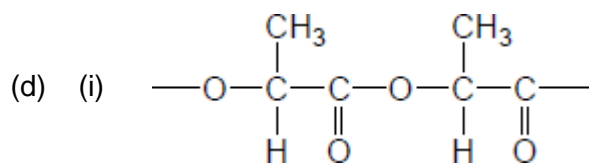
*Ignore reaction of  $\text{H}^+$  with  $\text{OH}^-$*

*Ignore reference to equilibrium unless it is shown.*

M4 ratio  $[\text{HA}] / [\text{A}^-]$  stays almost constant

*Ignore  $\text{H}^+$  or  $\text{pH}$  remains constant.*

**Max 2**



No marks if ester link missing

Correct ester link

allow  $\text{-COO-}$

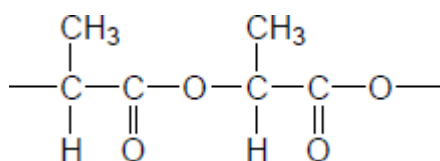
**NB Correct answer scores 2**

*Ignore n here (compare with (d)(iv)).*

*Ignore brackets*

1

**OR**



All rest correct with trailing bonds

*If OH or COOH on either or both ends, lose one, ie dimer scores 1*

*If more than two repeating units, lose 1*

1

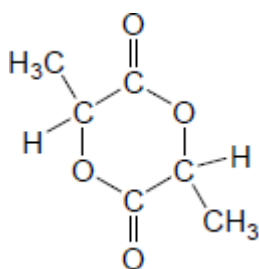
(ii) (Poly)ester ie allow ester

*Not terylene.*

*Ignore spaces and brackets in answer.*

1

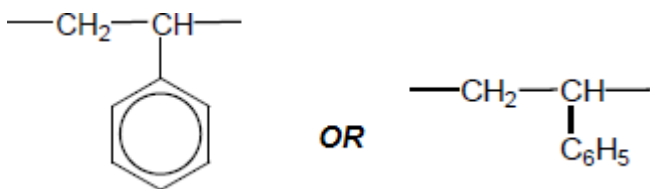
(iii)



Allow any cyclic  $\text{C}_6\text{H}_8\text{O}_4$

1

(iv)



*Penalise n here (compare with (d)(i))*

*Ignore brackets.*

*Not allow Ph for phenyl.*

1

(v) In landfill, no air or UV, to assist decay

**OR** not enough water or moisture (to hydrolyse polyester)

*Allow landfill has / contains:*

*no or few bacteria / micro-organisms / enzymes compared with  
compost heap*

**OR** less oxygen

**OR** lower temperature.

1

[22]

8

Dichromate(VI) will also oxidise / give a positive test with alcohols

*Allow 'dichromate'.*

*Allow 'dichromate(VI) will oxidise other organic molecules /  
functional groups'.*

[1]