

M1. (a) nucleophilic addition 1

*Attack by HCN loses M1 and M2
M2 not allowed independent of M1, but
allow M1 for correct attack on C+
+C=O loses M2
M2 only allowed if correct carbon attacked
allow minus charge on N i.e. :CN⁻*

4

M3 for completely correct structure not including lp
allow C₃H₇ in M3

M4 for lp and arrow
allow without –

1

2-hydroxy-2-methylpentan(e)nitrile
allow 2-hydroxy-2-methylpentanonitrile

(b) Product from **Q** is a racemic mixture/equal amounts of enantiomers
if no reference to products then no marks;

1

racemic mixture is inactive or inactive explained
not Q is optically active or has a chiral centre etc

1

Product from **R** is inactive (molecule) or has no chiral centre

1

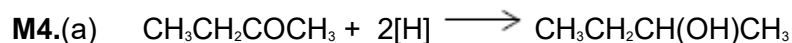
[9]

M2.D

[1]

M3.B

[1]



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^- 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

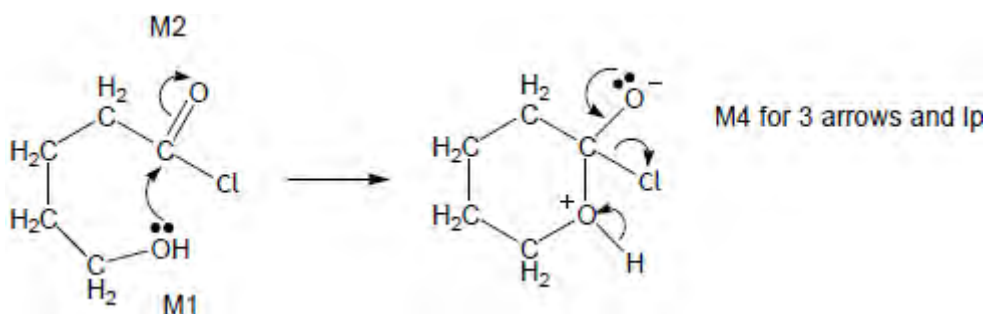
[7]

M5.(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.*

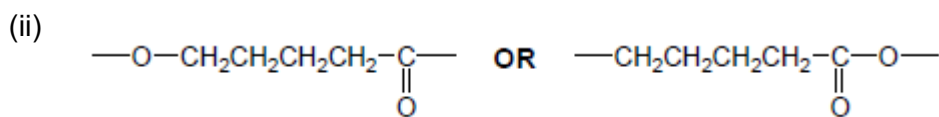
4

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

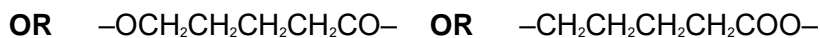
b 50-90 (ppm) or single value or range entirely within this range

1

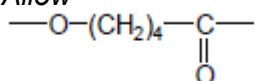


Must have trailing bonds, but ignore n.

1



Allow



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

one unit only

Condensation

1

(b)

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

1

J	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

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

J Two (peaks)
Allow trough, peak, spike.

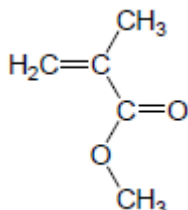
1

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 $H_2C=C(CH_3)COOCH_3$

All $C_5H_8O_2$ L to P must have $C=C$.

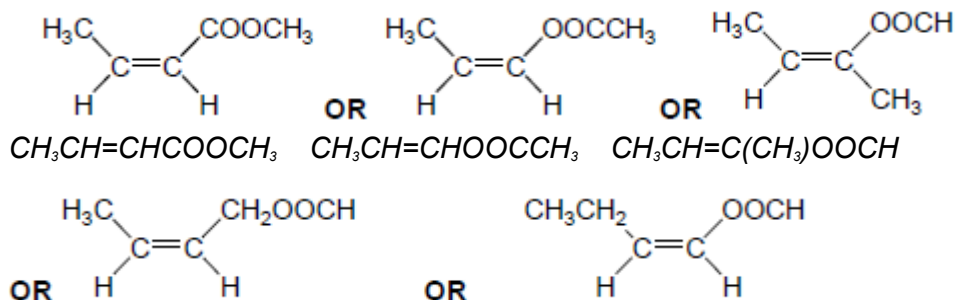
Allow CH_3^- .

Allow $-CO_2CH_3$ etc.

Allow $CH_2C(CH_3)COOCH_3$.

1

M
ester





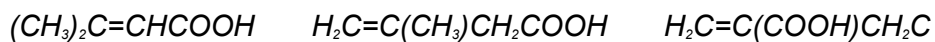
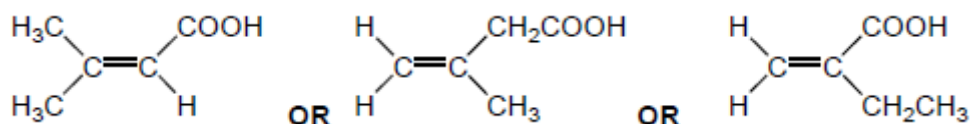
Allow either E-Z isomer.

Allow CH_3 - or C_2H_5 - but not CH_2CH_3 -.

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

1

N
acid



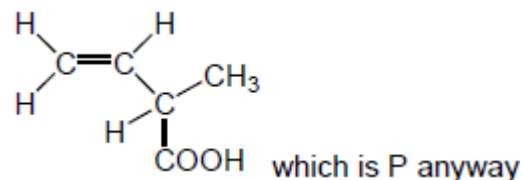
H_3

Allow CH_3 - or C_2H_5 - but not CH_2CH_3 -.

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

Not cyclic isomers.

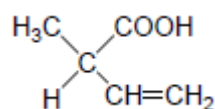
Not the optically active isomer.



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

1

P
acid



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

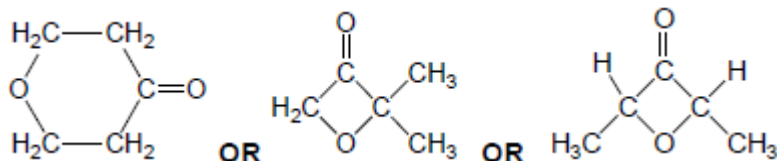


Allow $\text{CH}_3\text{CH}(\text{CO}_2\text{H})\text{CHCH}_2$ or



1

Q



Not cyclic esters.

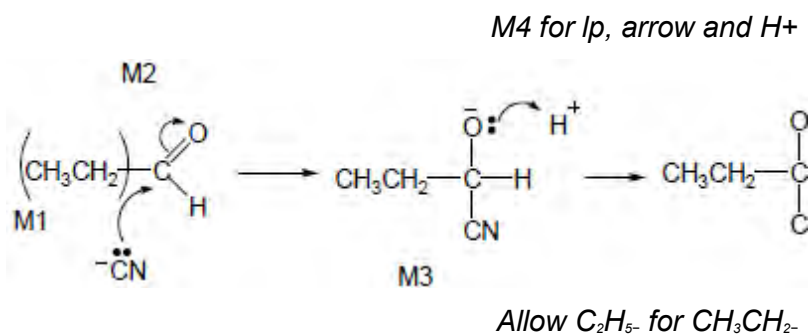
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[19]

M6.D

[1]

M7.(a) Nucleophilic addition

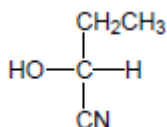
1



- M1 and M4 include lone pair and curly arrow.
- Allow: CN⁻ but arrow must start at lone pair on C.
- M2 not allowed independent of M1, but allow M1 for correct attack on C⁺.
- + rather than δ⁺ 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

(b) (i) M1



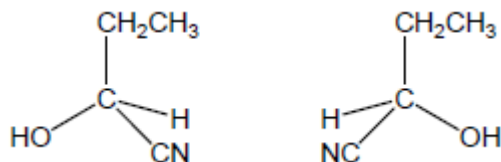
M1 for correct structure of product of part (a).

Allow C₂H₅- for CH₃CH₂-.

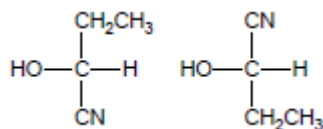
Penalise wrongly bonded, OH or CN or CH₂CH₃ once only in clip.

1

M2

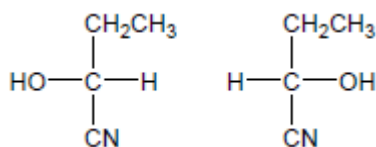


M2 cannot be gained by simply swapping two or more groups with no attempt to show a mirror image., e.g. do not allow M2 for



because these do not show the enantiomers as mirror images.

Students must show an attempt at mirror images, eg allow

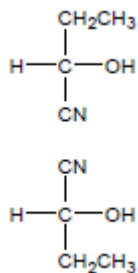


ie vertical groups same and horizontal swapped as if there was a mirror between them

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 light 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⁻] very low

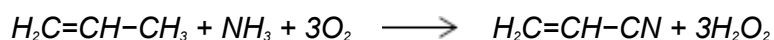
Allow (very) few cyanide ions.

Mark independently.

1

- (e) (i) $H_2C=CH-CH_3 + NH_3 + \frac{3}{2}O_2 \longrightarrow H_2C=CH-CN + 3H_2O$

OR

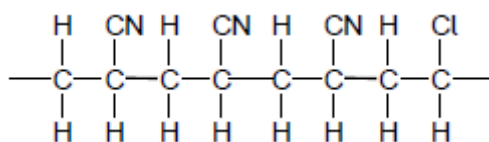


OR doubled.

Allow C₃H₆ and CH₂CHCN or C₃H₃N on this occasion only.

1

- (ii)

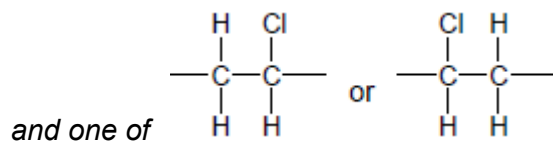
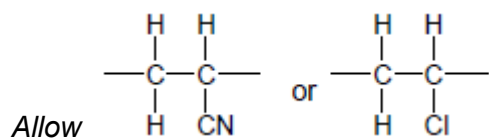
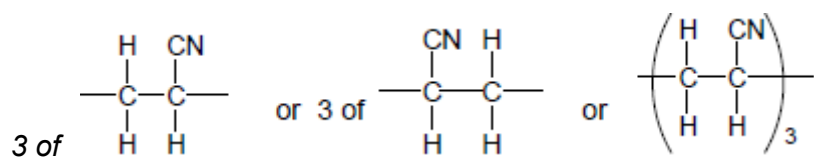


Ignore n.

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]