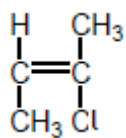


M1.(a)

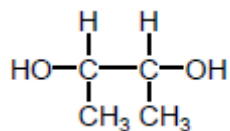


1

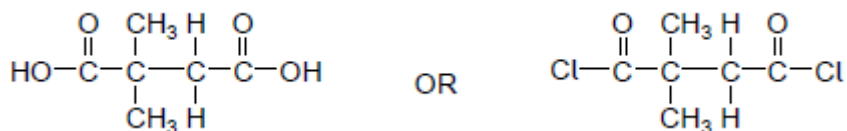
Addition

1

(b)



1



1

(c) **Q** is biodegradable

1

Polar C=O group or δ^+ C in **Q** (but not in **P**)

1

Therefore, can be attacked by nucleophiles (leading to breakdown)

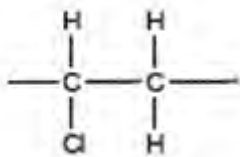
1

[7]

M2. (a) Benzene-1,2-dicarboxylic acid
Allow 1,2-benzenedicarboxylic acid

1

(b)



*Must show all bonds including trailing bonds
Ignore n*

1

- (c) (i) 2 C₂H₅OH
NB Two ethanols

1

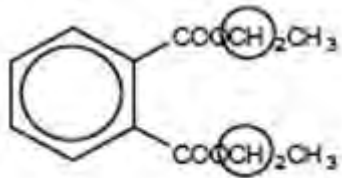
H₂O
but only one water

1

- (ii) 6 or six

1

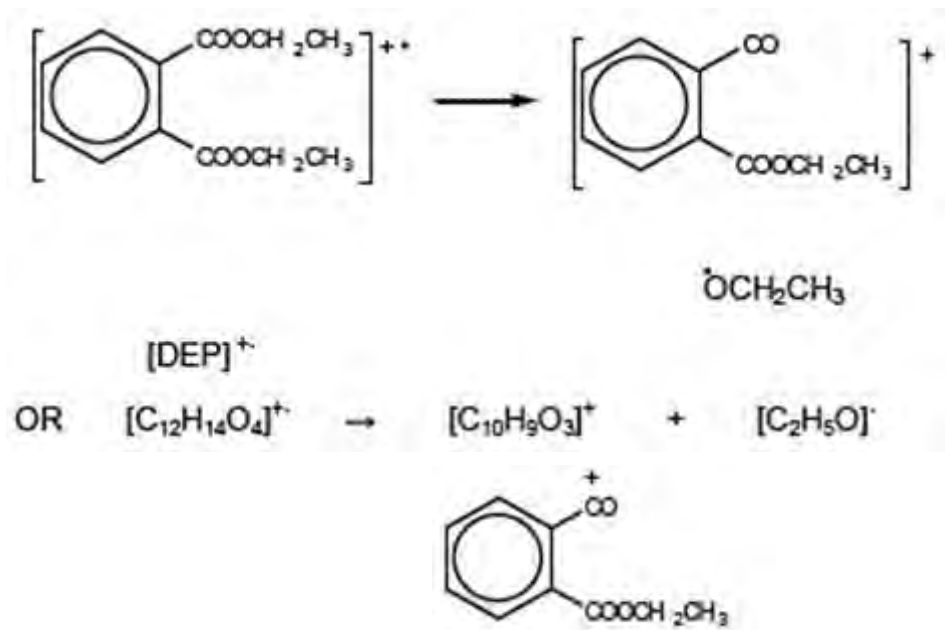
- (iii)



Ignore overlap with O to the left or H to the right, but must only include this one carbon. either or allow both (as they are identical)

1

(d)



Allow + on C or O in

1

Dot must be on O in radical

1

(e) (i) Rate = $k[DEP]$
 Must have brackets but can be ()

1

- (ii) Any **two** of
- experiment repeated/continued over a long period
 - repeated by independent body/other scientists/avoiding bias
 - investigate breakdown products
 - results made public
- Not just repetition*
Ignore animal testing

2 max

[11]

M3.(a) (i) 2-hydroxypropanoic acid
OR

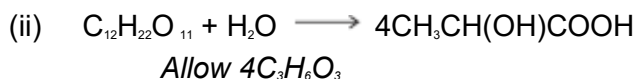
2-hydroxypropan(-1-)oic acid

Do not penalise different or missing punctuation or extra spaces.

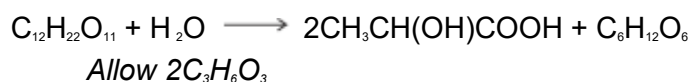
Spelling must be exact and order of letters and numbers as here.

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

1



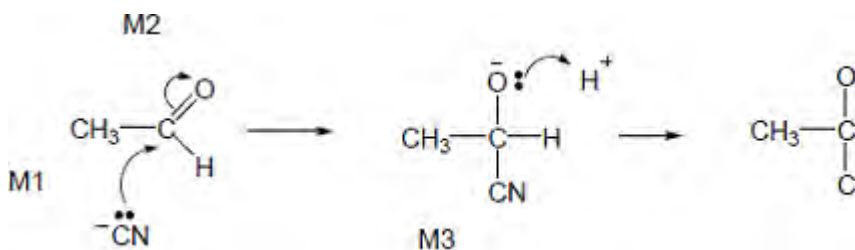
OR



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
If missing no further mark. 1

(Polarised light) rotated by single enantiomer but unaffected by racemate

Both needed; not allow bend, twist etc. 1

- (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 CO₂Na or COO⁻ or CO₂⁻ 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
Ignore acidic but penalise alkaline or basic. 1

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 A⁻ or sodium lactate or salt

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

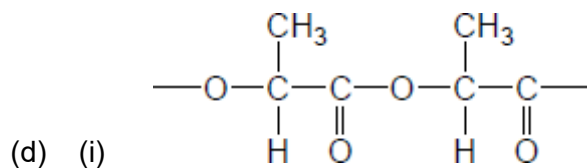
Ignore reaction of H⁺ with OH⁻

Ignore reference to equilibrium unless it is shown.

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

Ignore H⁺ or pH remains constant.

Max 2



No marks if ester link missing

Correct ester link
allow ---COO---

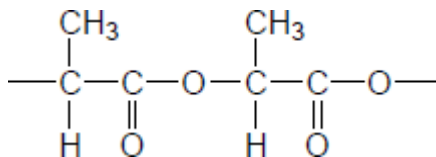
NB Correct answer scores 2

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

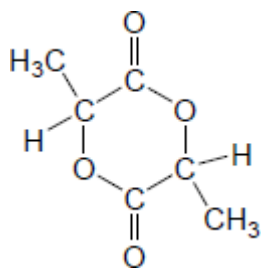
(ii) (Poly)ester ie allow ester

Not terylene.

Ignore spaces and brackets in answer.

1

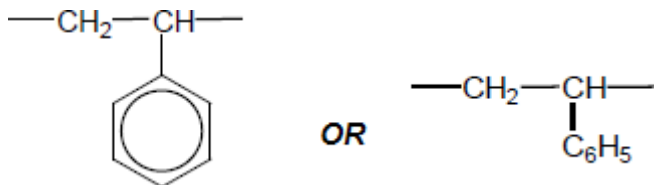
(iii)



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

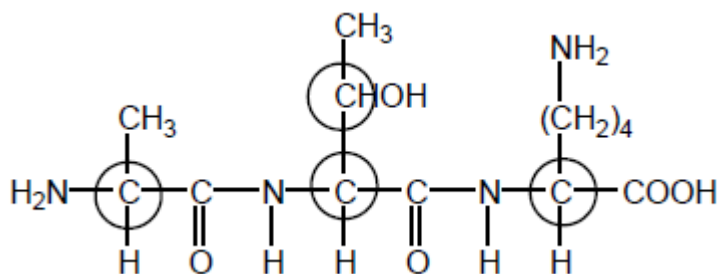
OR less oxygen

OR lower temperature.

1

[22]

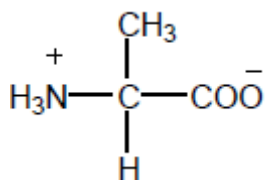
M4.(a) (i)



These four only

1

(ii)



Allow $-\text{NH}_3^+$ and $^+\text{NH}_3-$

1

(iii) 2-amino-3-hydroxybutanoic acid

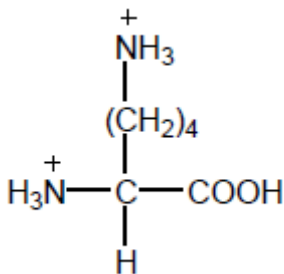
Ignore 1 in butan-1-oic acid

Do not penalise commas or missing hyphens

Penalise other numbers

1

(iv)



Allow $-\text{NH}_3^+$ and $^+\text{NH}_3-$

1

(b) (i) Condensation

Allow polyester

1

(ii) propane-1,3-diol

Must have e

Allow 1,3-propanediol

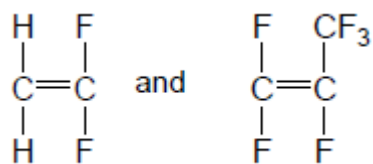
1

(c) (i) Addition

Not additional

1

(ii)

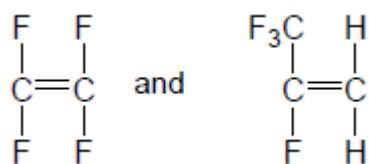


Allow monomers drawn either way round

Allow bond to F in CF₃

1

OR



1 for each structure within each pair

1

(d) c

If wrong, CE = 0

1

C-C or C-F bonds too strong

1

[11]