AQA A-LEVEL CHEMISTRY · 7405

CHEMISTRY



MARK SCHEME

3.3.4 ALKENES

SCORE	PERCENTAGE
/243	%

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Q1.

(a) **M1** C_nH_{2n+2}

1

M2 14.0*n* + 2.0 or 14n + 2

or 2(7.0n + 1.0) or 2.0(7n + 1) or 2(7n + 1)

1

(b) **M1** nonane has stronger / greater / more van der Waals' forces between molecules

or converse arguments for 2,4-dimethylbutane having lower boiling point

question refers to nonane if not expressly stated by candidate

intermolecular forces = forces between molecules

***M1** ignore abbreviations vdW and/or imf*

1

M2 nonane molecules pack closer together / more (surface) contact

***M2** ignore reference to surface area alone*

CE=0 reference to breaking (covalent) bonds / breaking chain

1

(c) $C_9H_{20} + 14O_2 \rightarrow 9CO_2 + 10H_2O$

allow multiples; ignore any state symbols; correct structures rather than formulae are fine

1

(d) **M1** nitrogen and oxygen from air react

***M1** must be at least one reference to air and no reference to nitrogen/oxygen coming from the fuel*

1

M2 at high temperature

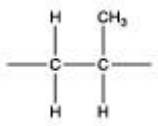
ignore reference to pressure, heat, hot, incomplete combustion

if temperature is stated, must be over 1000°C

1

(e) thermal (cracking)

1

(f) 

allow any correct structural representation

ignore any n or brackets

1

[9]

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Q2.

C

[1]

Q3.

(a) **M1** it / PVC is bigger/longer molecule / has more electrons / has bigger surface area / greater M_r

1

M2 it / PVC has stronger (van der Waals' / dipole-dipole) forces <u>between molecules</u> / <u>intermolecular</u> forces

1

__M1__ and __M2__ independent of each other

CE = 0 if reference to hydrogen bonds or breaking of covalent bonds when substances are melted

Comparison must be implied in __M1__ or __M2__ to score 2 marks

If there is no comparison at all, then 1 mark could score either for explaining that PVC has strong <u>intermolecular</u> forces due to being a big/long molecule / having many electrons / large surface area / large M_r, or, for explaining that chloroethene has weak <u>intermolecular</u> forces due to being a small/short molecule / having few electrons / low surface area / low M_r,

(b) 38

ignore additional words

1

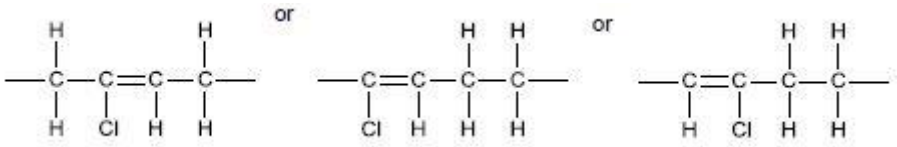
(c) Need both ideas that

- it is present AND
- because PVC needs to be flexible / bendy

penalise incorrect properties

1

(d) Displayed structure required



ignore any bracket or n

1

[5]

Q4.

A

[1]

Q5.

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(a) $Cl\bullet + O_3 \longrightarrow ClO\bullet + O_2$

Allow dot in free-radical on either O or Cl.

1

$ClO\bullet + O_3 \longrightarrow 2O_2 + Cl\bullet$

1

(b) (KOH acts as a) base

1

(propan-1-ol acts as a) solvent.

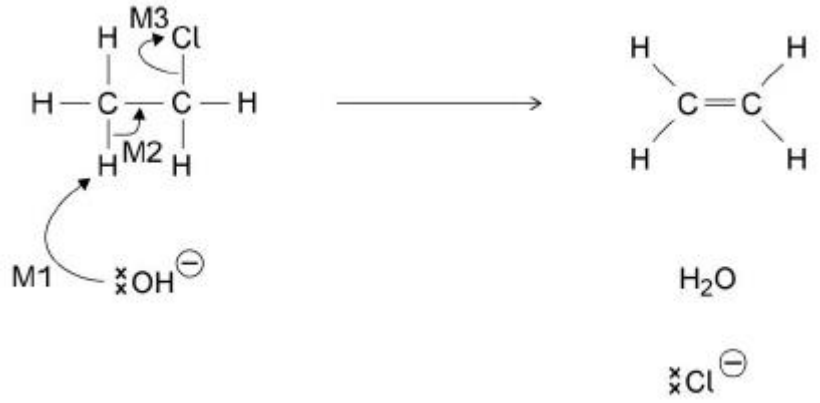
Allow product of reaction between KOH and propan-1-ol / $CH_3CH_2CH_2O^-$ acts as base.

1

(c) (Name of mechanism) Elimination

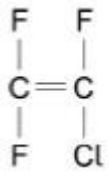
1

mechanism: 3 arrows (1 mark each).



3

(d)



1

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

Level 3

All stages are covered & the explanation of each stage is generally correct and virtually complete. Stages 1 and 2 are supported by correct data. Answer communicates the whole process coherently and shows a logical progression from stage 1 to stage 2 and then stage 3.

Steps in stage 3 are in logical order and working is shown. If there is no working for ratio or statement of ratio then full marks cannot be awarded.

If the formulae of the three molecular ions are not correct (2d) then the

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student can't access Level 3 (any incorrect chemistry drops the student to the bottom mark within the level they have achieved).

5-6 marks

Level 2

Stage 2 is attempted (**2a-2c** do not need to be explicitly stated) but the calculation may contain inaccuracies **OR** the explanation may be incomplete **OR** first two stages are covered and the explanations are generally correct and virtually complete. Answer is mainly coherent and shows a progression through the first two stages. Some steps in each stage may be incomplete.

If percentage of carbon is missing or incorrect (1a) then student can't access Level 2.

3-4 marks

Level 1

Stage 1 needs to be attempted but may contain inaccuracies.

OR

Stage 3 attempted but may contain inaccuracies / molecular formula not determined.

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

1-2 marks

Level 0

Insufficient correct chemistry to warrant a mark.

0 marks

Indicative Chemistry content

Stage 1 (determines empirical formula)

1a *16.3% carbon*

1b *Divide by* A_r

1c *Divide by smallest (0.904)*

1d *Convert ratio in simplest integer (x 2)*

C	Cl	F
$\frac{16.3}{12.0} = 1.358$	$\frac{32.1}{35.5} = 0.904$	$\frac{51.6}{19.0} = 2.716$
$\frac{1.358}{0.904}$	$\frac{0.904}{0.904}$	$\frac{2.716}{0.904}$
3	2	6

Stage 2 (determines formulae of three molecular ions)

2a *For E.F.* M_r *(corresponds to the molecule) = 221*

2b *since* M_r *= 221 lies within molecular ion range 220–224*

2c *Thus empirical formula = molecular formula*

2d *Three correct formulae*

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2e *Correct M_r for each of three molecules*

$C_3{}^{35}Cl_2F_6^+$	$C_3{}^{35}Cl^{37}ClF_6^+$	$C_3{}^{37}Cl_2F_6^+$
220	222	224

Stage 3 (explains the ratio of 3 molecular ion peaks)
3a *Working*
2b *Correct (simplified) ratio* ***9:6:1***
Note: 9:3:1 will be a common incorrect answer (max 5).

Working:

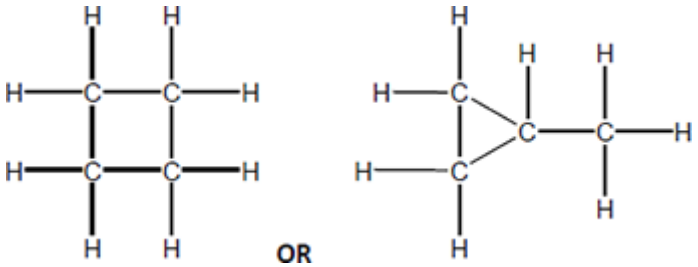
$C_3{}^{35}Cl_2F_6^+$	$C_3{}^{35}Cl^{37}ClF_6^+$	$C_3{}^{37}Cl_2F_6^+$
220	222	224
$^{35}Cl_2 = \left(\frac{3}{4}\right)^2 = \frac{9}{16}$	$^{35}Cl^{37}Cl$ and $^{37}Cl^{35} = 2 \times \frac{1}{4} \times \frac{3}{4} = \frac{6}{16}$	$^{37}Cl_2 = \left(\frac{1}{4}\right)^2 = \frac{1}{16}$

[15]

Q6.

(a) Alkenes

1



Correctly drawn molecule of cyclobutane or methyl cyclopropane, need not be displayed formula

1

(b) C_6H_{14} (or correct alkane structure with 6 carbons)

Allow hexane or any other correctly named alkane with 6 carbons

1

(c) Poly(but-2-ene)

1

(d) High pressure

Allow pressure □ MPa

Mention of catalyst loses the mark

1

(e) This question is marked using levels of response. Refer to the Mark Scheme

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Instructions for Examiners for guidance on how to mark this question.

Level 3

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

Answer communicates the whole process coherently and shows a logical progression from stage 1 and stage 2 (in either order) to stage 3.

5–6 marks

Level 2

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. Some steps in each stage may be out of order and incomplete.

3–4 marks

Level 1

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.

1–2 marks

Level 0

Insufficient correct chemistry to gain a mark.

0 marks

Indicative chemistry content

Stage 1*: consider effect of higher temperature on yield*

(Or vice versa for lower temperature)

- *Le Chatelier's principle predicts that equilibrium shifts to oppose any increase in temperature*
- *Exothermic reaction, so equilibrium shifts in endothermic direction / to the left*
- *So a Higher T will reduce yield*

Stage 2*: consider effect of higher temperature on rate*

(Or vice versa for lower temperature)

- *At higher temperature, more high energy molecules*
- *more collisions have E>Ea*
- *So rate of reaction increases / time to reach equilibrium decreases*

Stage 3*: conclusion*

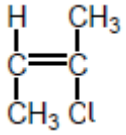
Industrial conditions chosen to achieve (cost-effective) balance of suitable yield at reasonable rate

[11]

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Q7.

(a)

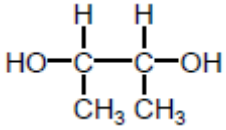


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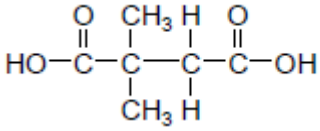
Addition

1

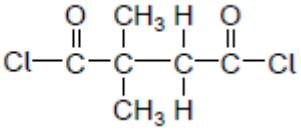
(b)



1



OR



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]

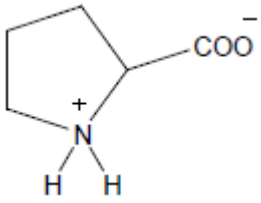
Q8.

D

[1]

Q9.

(a) (i)



Allow CO_2^- and NH_2^+

1

(ii) NOTE − **Two** marks for this clip

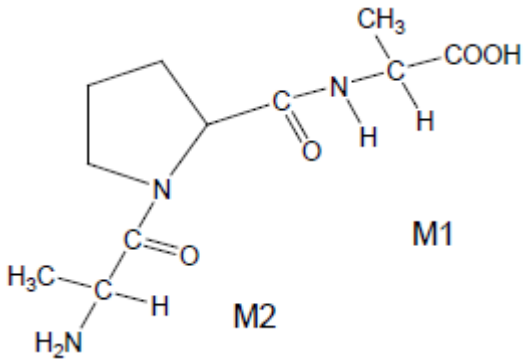
M1 for alanine section bonded through N

M2 for alanine section bonded through C

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But penalise error in proline ring

1



Allow MAX 1 for correct tripeptide in polymer structure

1

(b) (i) 3-methylpent-2-ene

Ignore E-Z, commas, spaces or missing hyphens

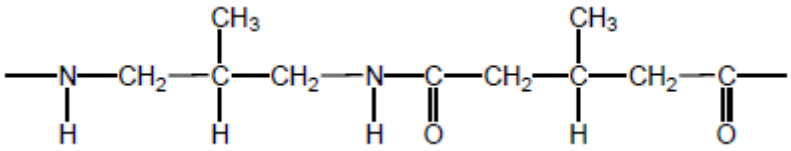
1

(ii) 4-amino-3-methylbutanoic acid

Ignore commas, spaces or missing hyphens

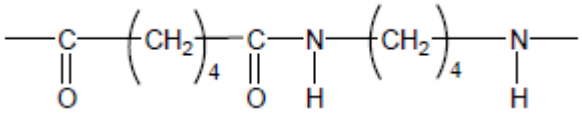
1

(iii)



or any polyamide section containing

8 carbons plus two C=O plus two N-H, such as



Trailing bonds are required

1

(iv) Non polar OR no polar groups / bonds (for attack by water / acids / alkalis / nucleophiles or for hydrolysis)

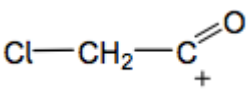
C-C bonds are strong

1

[7]

Q10.

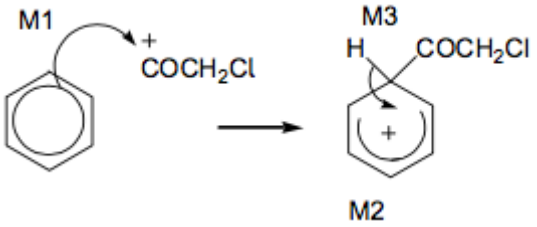
(a) (i)



Allow $[ClCH_2CO]^+$

1

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(ii)

M1 for arrow from inside hexagon to C or + on C on correct electrophile

M2 for structure of intermediate

- *Horseshoe centred on C1;*
- *+ in intermediate not too close to C1 (allow on or "below" a line from C2 to C6)*

M3 for Arrow from bond to H into ring

- *Allow M3 arrow independent of M2 structure*
- *+ on H in intermediate loses M2 not M3*
- *Ignore Cl- removing H^+*

1
1
1

(b) Reagent

Water

(Aqueous) silver nitrate

NaOH followed by acidified silver nitrate

(Water +) named indicator

Named alcohol
Na_2CO_3 or $NaHCO_3$
Ammonia

1

P

No reaction

No reaction (or slow formation of ppt)

No reaction (or slow formation of ppt)

No colour change

NVC
NVC
No reaction
Do NOT award
No observation

1

Q

Steamy /misty/ white fumes

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White precipitate (immediately formed)

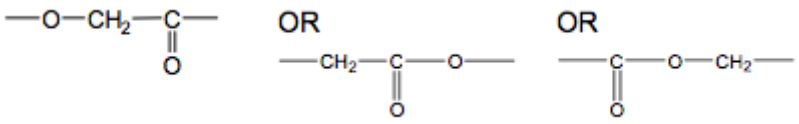
White precipitate (immediately formed)

Indicator turns to correct acid colour

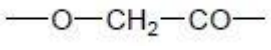
Fruity or sweet smell or misty fumes
Fizzing or effervescence (not just gas produced)
White smoke

1

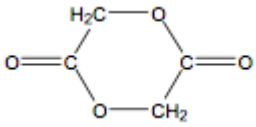
(c) (i)



One unit only
Must have trailing bonds
Ignore n and brackets

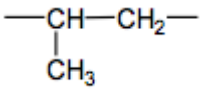
allow 

1

(i) 

Allow CO for C=O

1

(d) (i) 

One unit only
Must have trailing bonds
Ignore n and brackets

1

(ii) PGA sutures react/dissolve/break down/are biodegradable/ are hydrolysed / attacked by water or nucleophiles /no need to remove

OR Polypropene not biodegradeable/ not hydrolysed / not attacked by water/nucleophiles

1

(Ester links have) <u>polar bonds</u>

polypropene contains <u>non-polar bonds</u>
ignore intermolecular forces

1

[12]

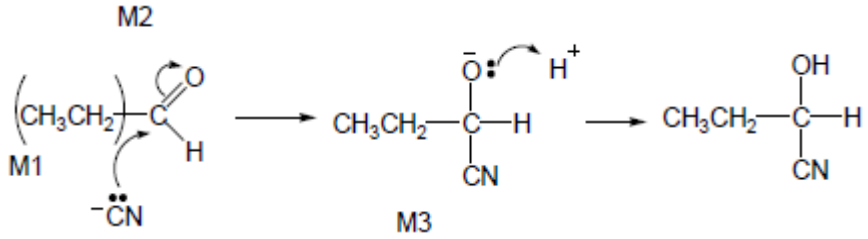
Q11.

(a) <u>Nucleophilic addition</u>

1

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M4 for lp, arrow and H+

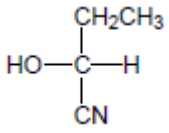


Allow C_2H_{5-} for CH_3CH_{2-}

- *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



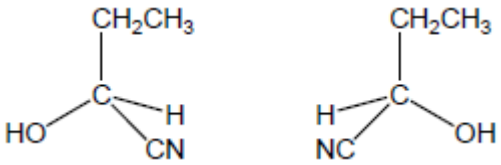
M1 for correct structure of product of part (a).

Allow C_2H_{5-} for CH_3CH_{2-}.

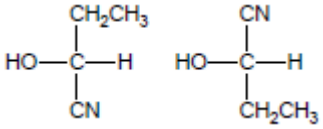
Penalise wrongly bonded, OH or CN or CH_2CH_3 once only in clip.

1

M2



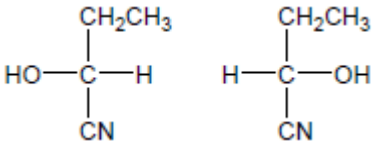
M2 cannot be gained by simply swapping two or more groups with no attempt to show a mirror image., e.g. do not allow M2 for



because these do not <u>show</u> the enantiomers as mirror images.

Students must <u>show</u> an attempt at mirror images, eg allow

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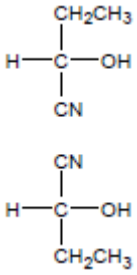


ie vertical groups same and horizontal swapped as if there was a mirror between them

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) <u>polarized light</u>

M2 only scores following correct M1

1

M2 <u>Rotated</u> in <u>opposite</u> 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) <u>2-hydroxybutane(-1-)nitrile</u>

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

$H_2C{=}CH{-}CH_3 + NH_3 + 3O_2 \longrightarrow H_2C{=}CH{-}CN + 3H_2O_2$

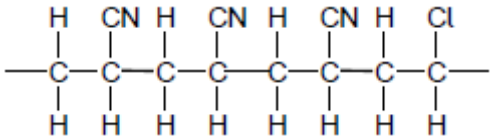
OR doubled.

Allow C_3H_6 and CH_2CHCN or C_3H_3N on this occasion only.

1

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(ii)

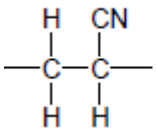
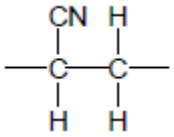
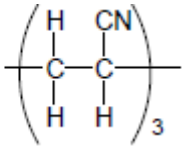


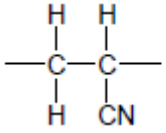
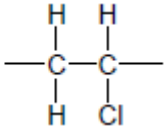
Ignore n.

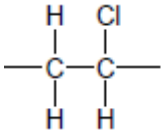
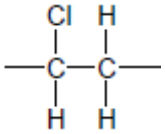
Must show trailing bonds.

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

Must contain, in any order,

3 of  or 3 of  or 

Allow  or 

and one of  or 

Allow –$CH_2CH(CN)CH_2CHCl$– etc.

1

(iii) Addition (polymerization)

Allow self-addition.

Do not allow additional.

1

[15]

Q12.

(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

$C_{12}H_{22}O_{11} + H_2O \longrightarrow 2CH_3CH(OH)COOH + C_6H_{12}O_6$

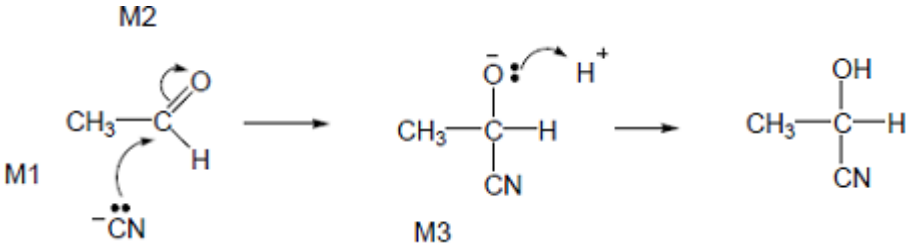
Allow $2C_3H_6O_3$

1

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(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 δ+ 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) $CH_3CH(OH)COOH + NaOH \rightarrow CH_3CH(OH)COONa + H_2O$
OR $CH_3CH(OH)COOH + OH^- \rightarrow CH_3CH(OH)COO^- + H_2O$

Not ambiguous mol formulae for product - must show COONa or CO_2Na or COO^- or CO_2^-

1

(ii) $[H^+] = K_a$ ***OR*** $pH = pK_a$

1

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

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M3 added acid reacts with / is removed by lactate ion or A^- or sodium lactate or salt
OR equation $H^+ + A^- \rightarrow HA$

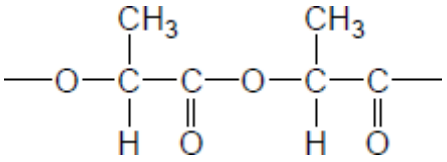
Ignore reaction of H^+ with OH^-
Ignore reference to equilibrium unless it is shown.

M4 ratio [HA] / [A^-] stays almost constant

Ignore H^+ or pH remains constant.

Max 2

(d) (i)



No marks if ester link missing

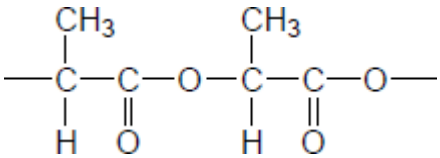
Correct ester link
allow –COO–

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

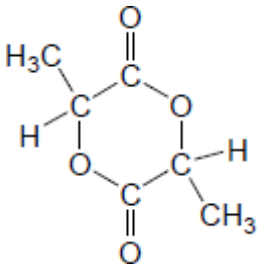
(ii) (Poly)ester ie allow ester

Not terylene.

Ignore spaces and brackets in answer.

1

(iii)

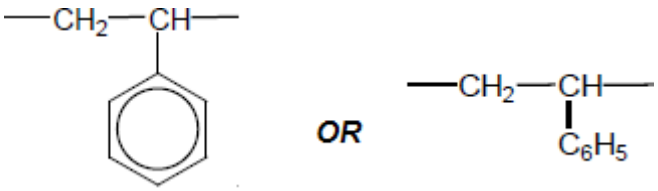


Allow any <u>cyclic $C_6H_8O_4$</u>

1

(iv)

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OR

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*

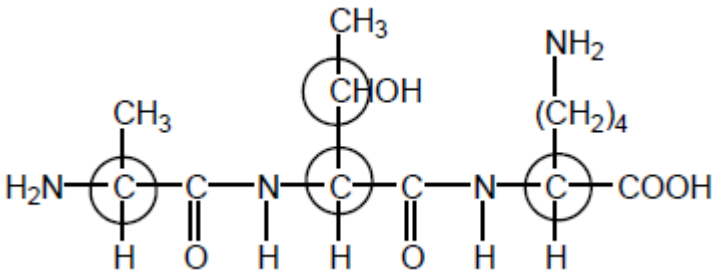
OR *<u>lower</u> temperature.*

1

[22]

Q13.

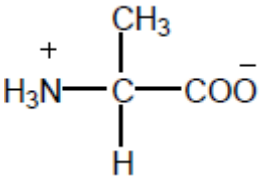
(a) (i)



These four only

1

(ii)



Allow − NH_3^+ and $^+NH_3^-$

1

(iii) <u>2-amino-3-hydroxybutanoic acid</u>

Ignore 1 in butan-1-oic acid

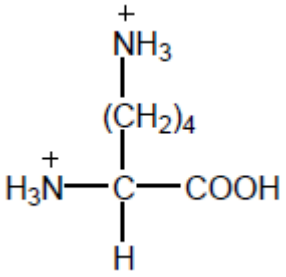
Do not penalise commas or missing hyphens

Penalise other numbers

1

(iv)

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Allow $-NH_3^+$ and $^+NH_3-$

1

(b) (i) Condensation

Allow polyester

1

(ii) propan**e**-1,3-diol

Must have e

*Allow 1,3-propan**e**diol*

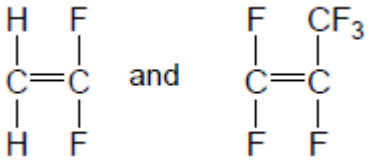
1

(c) (i) Addition

Not additional

1

(ii)

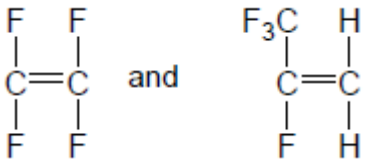


Allow monomers drawn either way round

Allow bond to F in CF_3

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

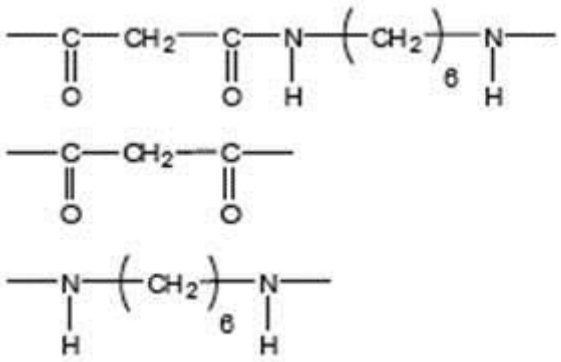
1

[11]

Q14.

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(a) (i)



Allow –CONH- or - COHN -

Mark two halves separately

lose 1 each for missing trailing bonds at one or both ends or error in peptide link or either or both of H or OH on ends

1

Not allow –(C_6H_{12})–

Ignore n

1

(ii) **M1** in polyamides - H bonding

1

M2 in polyalkenes - van der Waals forces

Penalise forces between atoms or van der Waals bonds

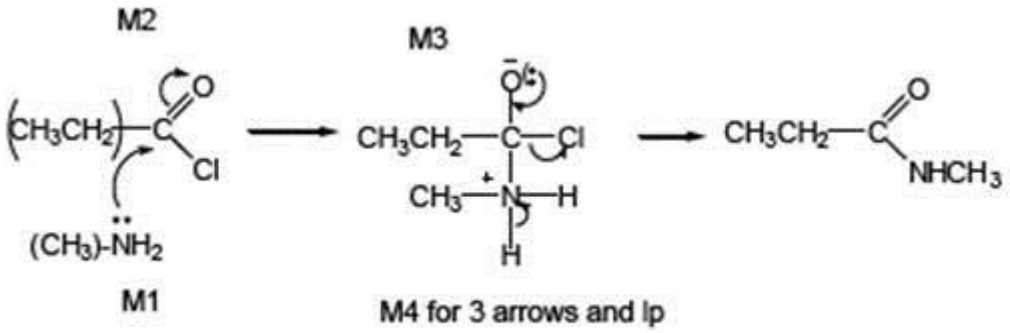
1

M3 Stronger forces (of attraction) in polyamides
Or H bonding is stronger
(must be a comparison of correct forces to score M3)

Do not award if refer to stronger bonds

1

(b) (i) (nucleophilic) addition elimination



Not allow N–H_2

*Minus sign on NH_2 loses **M1***

1

*M2 not allowed independent of **M1**, but allow **M1** for correct attack on C+*

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*+ rather than δ+ on C=O loses **M2***
*If Cl lost with C=O breaking, max 1 for **M1***
***M3** for correct structure <u>with charges</u> but*
*lp on O is part of **M4***
*only allow **M4** after correct/ very close M3*
For M4, ignore NH_3 removing H^+ but lose
***M4** for Cl removing H^+ in mechanism,*
but ignore HCl as a product

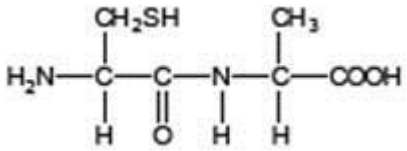
4

(ii) <u>N-methylpropanamide</u>

Not N-methylpropaneamide

1

(c)



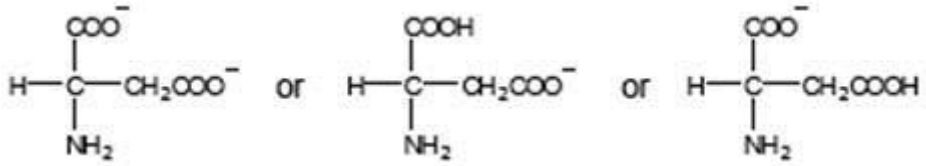
Allow –CONH– or –COHN–

1

(d) (i) <u>2-amino-3-hydroxypropanoic acid</u>

1

(ii)

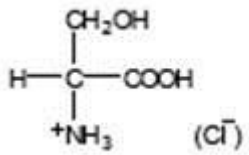


Must be salts of aspartic acid

allow $–CO_2^-$
allow NH_2–

1

(iii) Penalise use of aspartic acid once in d(iii) and d(iv)

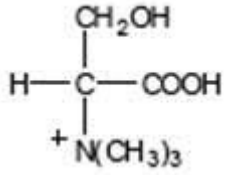


allow $–CO_2H$
allow $^+NH_3$–
don't penalize position of + on NH_3

1

(iv) Penalise use of aspartic acid once in d(iii) and d(iv)

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(Br^-)

allow $-CO_2^-$
must show C-N bond
don't penalize position of + on $N(CH_3)_3$

1

[16]

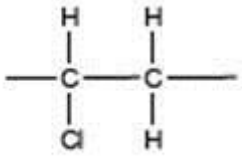
Q15.

(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) $2\ C_2H_5OH$

NB Two ethanols

1

H_2O

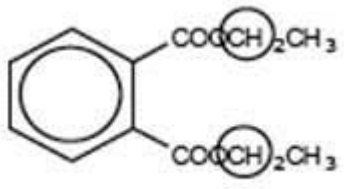
but only one water

1

(ii) 6 or six

1

(iii)

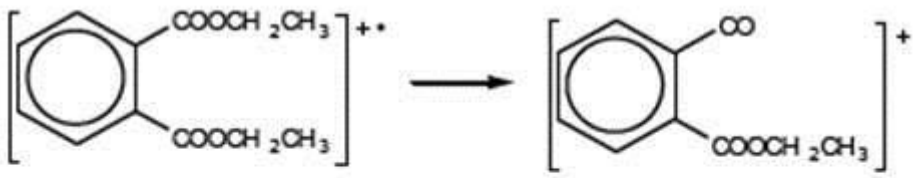


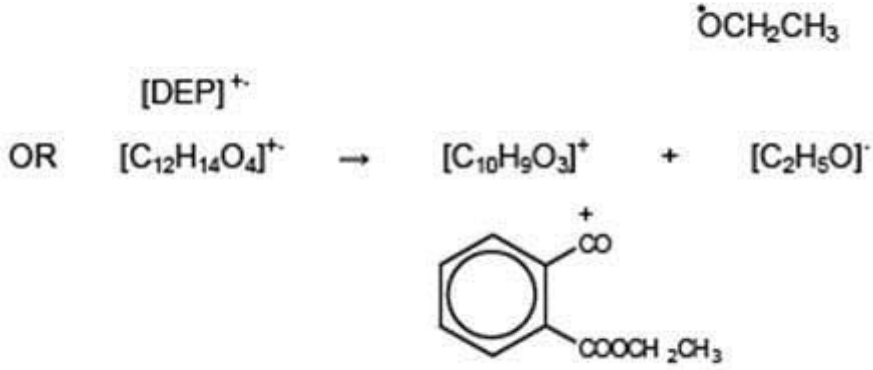
Ignore overlap with O to the left or H to the right, but must only include this one carbon.
either or allow both (as they are identical)

1

(d)

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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 <u>over a long period</u>
- repeated by independent body/other scientists/avoiding bias
- investigate breakdown products
- results made public

Not just repetition

Ignore animal testing

2 max

[11]

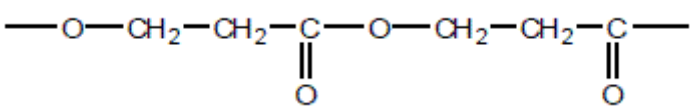
Q16.

(a) 3-hydroxypropanoic acid

allow 3-hydroxypropionic acid
must be correct spelling

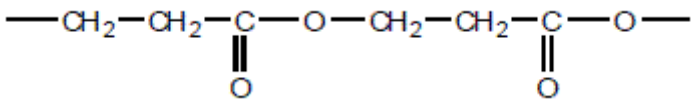
1

(b) (i) must show trailing bonds



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or can start at any point in the sequence, e.g.



not allow dimer
allow –O–$CH_2CH_2COOCH_2CH_2CO$–
or –$CH_2CH_2COOCH_2CH_2COO$–
ignore ( ) or n
NB answer has a total of 6 carbons and 4 oxygens

1

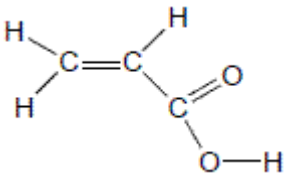
(ii) condensation (polymerisation)
Allow close spelling

1

(c) (i) C=C or carbon-carbon <u>double</u> bond

1

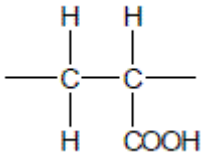
(ii)



*must show **ALL** bonds including O–H*

1

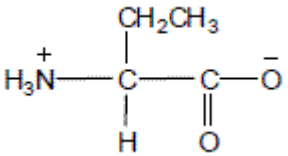
(iii) must show trailing bonds



allow polyalkene conseq on their c(ii)
ignore n

1

(d)

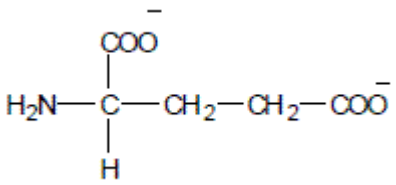


allow NH_3^+—
allow COO^-

1

(e) (i)

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In (e), do not penalise a slip in the number of carbons in the -CH_2CH_2- chain, but all must be bonded correctly

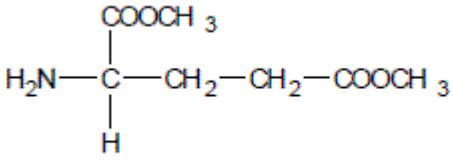
NB two carboxylate groups

Allow COONa or COO^- Na^+ but not covalent bond to Na

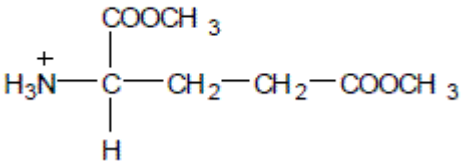
allow NH_2–

1

(ii)



OR



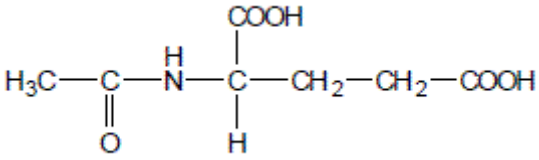
In (e), do not penalise a slip in the number of carbons in the -CH_2CH_2- chain, but all must be bonded correctly

NB two ester groups

allow NH_2– or $^+NH_3$–

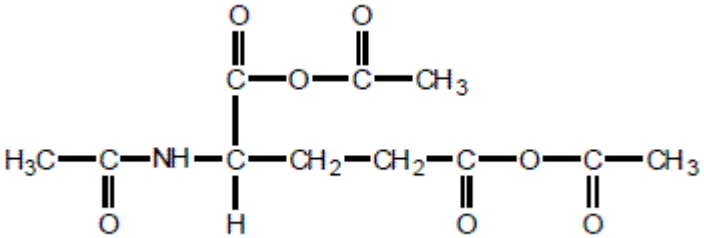
1

(iii)



In 4(e), do not penalise a slip in the number of carbons in the -CH_2CH_2- chain, but all must be bonded correctly

allow anhydride formation on either or both COOH groups (see below) with or without amide group formation



1

(f) **M1** phase or eluent or solvent (or named solvent) is <u>moving or mobile</u>

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1

M2 stationary phase or solid or alumina/silica/resin

1

M3 separation depends on balance between solubility or affinity (of compounds) in each phase
OR
different adsorption or retention
OR
(amino acids have) different R_f values
OR
(amino acids) travel at different speeds or take different times

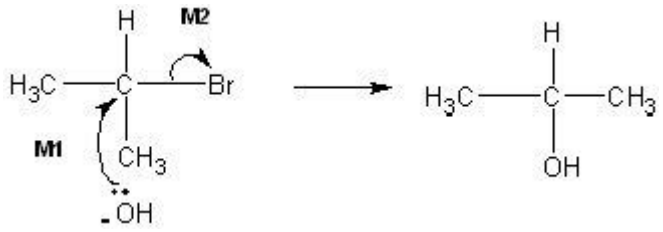
1

[13]

Q17.

(a) (i) Nucleophilic substitution

1



2

M1 must show an arrow from the lone pair of electrons on the oxygen atom of the negatively charged hydroxide ion to the central C atom.
M2 must show the movement of a pair of electrons from the C-Br bond to the Br atom. Mark M2 independently.

Penalise M1 if covalent KOH is used

Penalise M2 for formal charge on C or incorrect partial charges

Penalise once only for a line and two dots to show a bond.

*Max 1 mark **for the mechanism** for the wrong reactant and/or "sticks"*

Ignore product

Award full marks for an S_N1 mechanism in which M1 is the attack of the hydroxide ion on the intermediate carbocation.

(ii) 2-bromopropane ONLY

1

(iii) Polar C–Br ***OR*** polar carbon–bromine bond ***OR*** dipole on C–Br ***OR*** δ+ (δ–)
C atom of carbon–bromine bond is δ+/electron deficient ***OR*** C—Br

(Credit carbon–halogen bond as an alternative to carbon–bromine bond)

It must be clear that the discussion is about the carbon atom of the C–Br bond. NOT just reference to a polar molecule.

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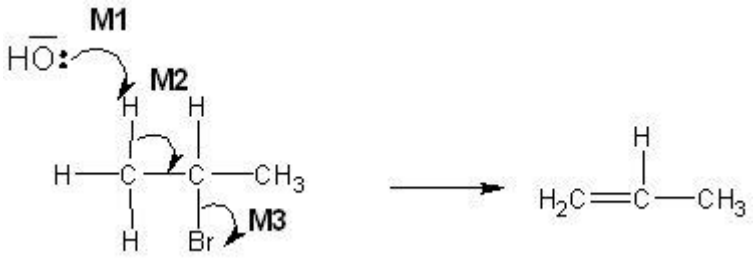
Ignore X for halogen

1

(b) Elimination

Credit "base elimination" but NOT "nucleophilic elimination"
No other prefix.

1



3

M1 must show an arrow from the lone pair on oxygen of a negatively charged hydroxide ion to the correct H atom
M2 must show an arrow from the correct C-H bond to the C-C bond and should only be awarded if an attempt has been made at M1
M3 is independent.

Mechanism
Penalise M1 if covalent KOH
Penalise M3 for formal charge on C or incorrect partial charges
Penalise once only for a line and two dots to show a bond.
*Max 2 marks **for the mechanism** for wrong reactant and/or "sticks"*
Ignore product

Award full marks for an E1 mechanism in which M2 is on the correct carbocation.

(c) *Any one condition from this list to favour elimination*;

Apply the list principle

- alcohol(ic)/ethanol(ic) (solvent)
- high concentration of KOH/alkali/hydroxide ***OR*** concentrated KOH/hydroxide
  Ignore "aqueous"
- high temperature or hot or heat under reflux or T = 78 to 100°C
  Ignore "excess"

1

(d) (i) Addition (polymerisation) ONLY

Penalise "additional"

1

(ii) But-2-ene ONLY (hyphens not essential)

Ignore references to cis and trans or E/Z
Ignore butane

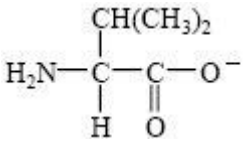
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1

[12]

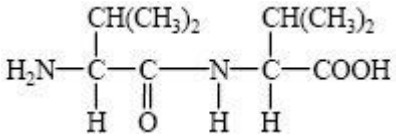
Q18.

(a) (i)



1

(ii)



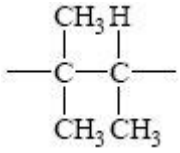
1

(iii) hydrogen bonding (do not allow H-bonding) QWC

do not penalise any error twice.

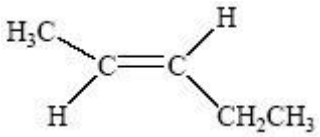
1

(b) (i)



1

(ii)

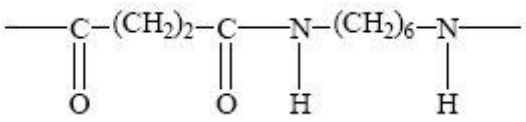


1

(iii) Isomer must be saturated or must not contain a double bond

1

(c)



2

(d) (i) heat/reflux with aqu NaOH

1

poly(alkene) is inert/ no reaction

1

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polyamide is <u>hydrolysed</u> (or undergoes <u>hydrolysis</u>) to form acid salt and alcohol QWC

1

(ii) e.g combustion

1

heat energy produced

1

toxic gases produced

1

[14]

Q19.

(a) (i) $CH_3CH=CHCH_3$

1

Addition or radical (**QoL**)

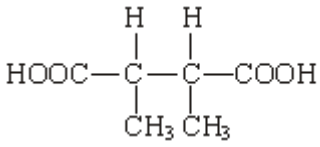
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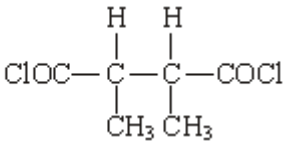
(ii) $CH_3CH(OH)CH(OH)CH_3$ or with no brackets

1

butan(e)–<u>2,3</u>–diol or <u>2,3</u>–butan(e)diol

1



allow 

1

<u>2,3</u>–dimethylbutan(e)dioic acid <u>2,3</u>–dimethylbutan(e)dioyl chloride

ignore –1,4–

1

condensation (**QoL**)

1

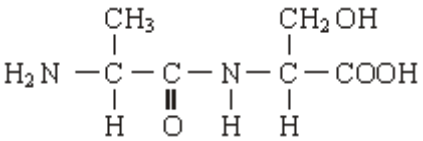
(iii) NaOH or HCl etc or Na_2CO_3

Allow conc sulphuric/nitric

***NOT** water nor acidified water nor weak acids*

1

(b) Structure 1



Allow –CONH– and –COHN–

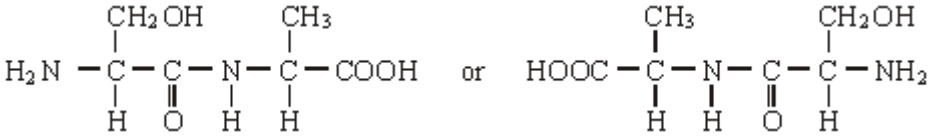
Allow zwitterions

NOT polypeptides/repeating units

1

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Structure 2 either of

 or

1

(c) (i) $CH_3CH_2CH_2Br$

allow –Cl, –I

1

(ii) CH_3CH_2CN

1

(iii) (nucleophilic) substitution or from $CH_3CH_2CH_2Br$

if reduction written here, no further marks

1

further substitution/reaction occurs or other products are formed

Allow reduction forms only one product

1

one of
$(CH_3CH_2CH_2)_2NH$
$(CH_3CH_2CH_2)_3N$
$(CH_3CH_2CH_2)_4N^+ Br^-$

Allow salts including NH_4Br

Allow HBr

1

[15]

Q20.

(a) M1 fermentation

1

M2 dehydration or elimination

1

(b) (i) yeast OR zymase OR an enzyme

1

(ii) <u>concentrated</u> sulphuric or phosphoric acid

(penalise aqueous or dilute as a contradiction)

1

(c) (i) primary or 1°

1

(ii) sugar or glucose or ethanol is renewable
OR ethanol does not contain sulphur-containing impurities
OR ethanol produces <u>less</u> pollution or is <u>less</u> smoky or <u>less</u> CO/C

(the objective is a positive statement about ethanol)
(penalise the idea that ethanol is an infinite source or vague statements that ethanol has less impurities) (penalise the idea that ethanol produces no pollution)

1

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(d) $C_2H_6 \rightarrow C_2H_4 + H_2$

1

(e) Addition

(ignore self or chain as a preface to "addition ")
(penalise additional)

1

[8]

Q21.

(a) (i) moles of C_2F_2 = 0.40 mark independently from HC1

1

moles of HC1 = 0.80 **not** consequential

1

(ii) $K_c = \frac{[C_2F_4][HCl]^2}{[CHClF_2]^2}$

wrong K_c means they can only

score for units in (iii) consequ

on their K_c

1

(iii) $K_c = \frac{(0.40/18.5)(0.8/18.5)^2}{(0.20/18.5)^2}$

1

= 0.35

1

mol dm^{-3}

1

(b) (i) increase

1

(ii) decrease

1

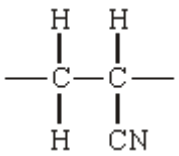
(c) addition or radical

1

[9]

Q22.

(a) (i)



(Ignore n or brackets, but trailing bonds are essential)

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1

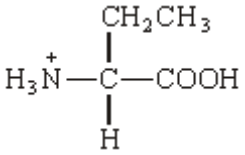
(ii) Addition or radical

1

(b) (i) 2-aminobutanoic (acid)

1

(ii)

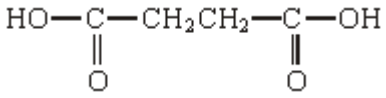


1

(c) (i) $C_3H_4O_2$

1

(ii)



1

(1,4-)butan(e)dioic (acid)

(allow succinic, but not dibutanoic nor butanedicarboxylic acid)

1

(iii) Can be hydrolysed / can react with acid or base or water / can react with nucleophiles

1

[8]

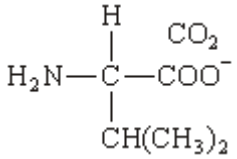
Q23.

A

[1]

Q24.

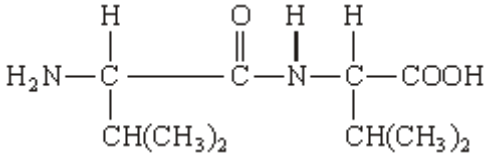
(a) (i)



(1)

ignore Na^+ unless covalently bonded

(ii)



(1)

must be dipeptide, not polymer nor anhydride
allow –CONH– or –COHN–

allow zwitterion

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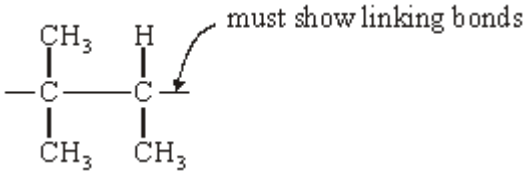
(iii) hydrogen bonding **(1)**

QL

Allow with dipole-dipole or v derWaals, but not dipole-dipole etc alone

3

(b) (i) *Type of polymerisation*: addition(al) **(1)**



Repeating unit: **(1)**

not multiples

allow n

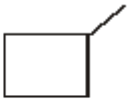
(ii) $CH_3CH=CHCH_2CH_3$ **(1)** C_2H_5

(iii)

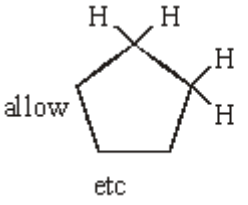


(1)

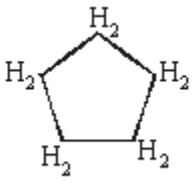
or



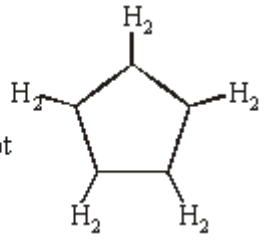
etc



or



but not



4

[7]

Q25.

B

[1]

Q26.

(a) *Electrophile*: e^- pair / lone pair acceptor or e^- deficient species or e^- seeking species **(1)**

For 'species' accept atom, molecule, ion
NOT '+' ion
NOT 'attracted to '-' charge'

Addition: reaction which increases number of substituents or convert double bond to single bond or where two molecules form one molecule **(1)**

2

(b) (High) e^- dense or e^- rich C=C or e^- rich π bond or 4 e^- between the C's **(1)**

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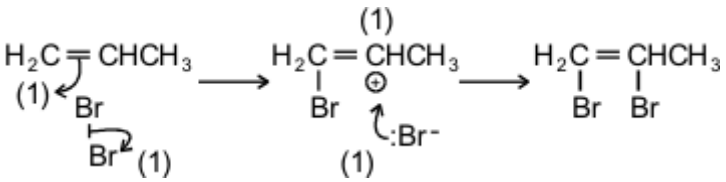
NOT just 'C=C'

causes induced dipole in Br_2 **(1)**

Ignore refs to 'temporary'
can score M2 from δ^+ / δ^- on Br_2 in (c) unless a contradicting error in (b)

2

(c) *Mechanism:*



If incorrect alkene, lose M3 (wrong cation)
Mark M4 conseq on M3

If M1 curly arrow C=C allow

Name of product: 1,2-dibromopropane **(1)**

5

(d) addition **(1)**

Not additional

1

[10]

Q27.

A

[1]

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Q1.

(a) Most students knew the general formula of alkanes and many could also deduce the M_r in terms of n, where n is the number of C atoms.

(b) A lot of students believed that covalent bonds break when alkanes are boiled. Other students lost a mark for poor use of terminology by not referring to forces between molecules. 62.2% of students failed to score on this question.

(c) Nearly all students (82.8%) could write the balanced equation for the complete combustion of nonane.

(d) A good number of students knew how NO is formed in an engine, but many did not appreciate that the nitrogen comes from the air and that high temperatures are required for the formation of NO.

(e) Most students (75.7%) knew that thermal cracking is used to form alkenes.

(f) Few students (30.9%) could draw the repeating unit of poly(propene) correctly.

Q2.

Many students (52.2%) got this question correct but many others incorrectly thought that the polymer contained a C=C bond and would decolourise bromine water.

Q3.

(a) Many students believed incorrectly that covalent bonds break when PVC melts and failed to score on this question.

(b) This question required students to know how many hydrogen atoms were on each carbon atom in a skeletal structure, but many struggled to count them correctly.

(c) Very few students appeared to know why plasticisers are added to some polymers. This is new content for this specification.

(d) This question required students to draw the displayed structure of a repeating unit and proved to be challenging.

Q9.

Part (a)(i) was very well done, although some answers included too many hydrogens on the nitrogen of proline. Part (a)(ii) was less well answered; some students drew the nitrogen atom either not in the ring or with a hydrogen atom attached. A few misread the question and used two proline molecules.

The name in part (b)(i) was well answered but that in (b)(ii) was found more difficult. Part (b)(iii) was answered correctly by about a third of the students. The most common error was not forming the polymer from a dicarboxylic acid and a diamine, but instead using amino carboxylic acids. A small number of students did not give the correct number of C atoms in the polymer section. Part b(iv) was well understood with strong C-C bonds being the most common correct answer.

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Q10.

Apart from the occasional suggestion of $AlCl_4^-$ as the electrophile, part (a)(i) was answered well as was the mechanism in (a)(ii). Marks are still lost by some students who draw curly arrows that lack the precise start and end positions required to gain the mark. About a third of students scored full marks in part (b). The vast majority of incorrect answers involved oxidation: using Tollens or Fehling's or acidified potassium dichromate solution. Students should be reminded that when asked to give an observation, those who write the word "nothing" or "no observation" will not gain a mark.

Part (c)(i) was answered well although a few students drew more than one repeating unit. Part (c)(ii) was also answered well. About a third of students did not answer part (d)(i) correctly. Part (d)(ii) proved a good differentiator with many gaining a mark for noting that PGA is biodegradable, but only the best students were able to link this to the presence of polar bonds in PGA. Some students included the term polar but applied it to the whole molecule and not a specific bond.

Q11.

In part (a), the nucleophilic addition mechanism was very well done; common errors included missing the charge on the nucleophile or on the intermediate structure and showing a bond between the carbonyl carbon and the N of CN in the intermediate. In part (b)(i), students were not used to drawing 3D structures, and credit was given where attempts showed a pair of mirror images. Again there were some problems with wrongly bonded OH, CN and CH_2CH_3 groups in these structures. The method needed to distinguish between two enantiomers was well known, although to gain M2 polarised light had to be 'rotated' not turned or reflected, and rotated in 'opposite' directions not just different directions. A few students suggested wrongly that the molecules polarised the light or that the molecules themselves were rotated. The name in part (c) was well answered but part (d) was answered poorly. There was confusion of K_a, the acid dissociation constant, with a rate constant, and many students missed the link to low concentrations of cyanide ions from the weak acid HCN and focused mainly on the rate of the dissociation of the acid. Parts (e)(i) and (e)(iii) were answered well but responses to part (e)(ii) sometimes included the C=C bond or the CN group as part of the polymer chain.

Q12.

Parts (a), (b)(i) and (b)(ii) were answered well. In part (b)(iii), students often correctly identified that polarised light could be used but then failed to gain the marks because they did not mention the effect of a racemic mixture on the light. Another concern was that answers appeared to suggest that the light caused the molecules themselves to rotate.

Parts (c)(i) and (c)(ii) were answered well but very few students scored full marks for part (c)(iii) where explanations were often muddled or referred to unspecified equilibria.

Part (d) was generally well attempted, with the main errors being in part (d)(i), where many gave three or more repeating units or failed to show an ester linkage, in part (d)(iv), where many gave the formula of the polymer or missed this part out completely, and in part (d)(v), where hydrogen bonding was often offered as an explanation.

Part (d)(iii) contained an unfortunate typographical error, which was identified after the examination had taken place. The end of the first sentence should have read "...from two lactic acid molecules" rather than ".....from two PLA molecules". AQA apologises for this error. The expected answer was given by about a quarter of the students. To ensure that students were not disadvantaged, a mark was also awarded to those students who drew any correct cyclic compound with molecular formula C6H8O4. The number of students

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who did not attempt this question was low and in line with other question parts on this paper. The most common errors involved attempts to draw a cyclic compound but with one or more carbons having fewer than four bonds or oxygens with fewer than two bonds.

Q13.

Part (a)(i) was only answered correctly by 28% of students but the rest of part (a) was well done including the name in part (a)(iii) although some had the prefixes in the wrong order or had the numbers reversed.

Part (b)(ii) was not well done. The 'e' is required in the names of diols, triols etc as in the example here, propane-1,3-triol.

There were very few wrong answers in part (c).

Many students scored 1 mark in part (d) for identifying the correct compound as 'c', but the explanations were almost always incorrect. The C-F bond in the copolymer is polar but is not hydrolysed because it and all other bonds in the compound are strong.

Q14.

The repeating unit in part (a)(i) was generally well attempted, although a number of benzene rings appeared in place of (CH2)6 in the diamine section. Part (a)(ii) was less well done; many candidates omitted the name of the relevant intermolecular force in both types of polymers or gave dipole-dipole attractions as the strongest type in polyamides. Some sadly described breaking bonds in the carbon chains.

Part (b)(i) was well answered although some common errors continue to appear. These include writing a minus charge on methylamine, omitting the + on the N in the intermediate and drawing the curly arrow which shows breaking of the N-H bond going to the H rather than to the N. Many gave the correct name in (b)(ii), but an appreciable number of candidates were unfamiliar with naming of N-substituted amides or did not recognise the product as one of these.

Part (c) was well answered but by contrast part (d)(i) was not. Even candidates who identified the correct substituents failed to write them in alphabetical order or gave the wrong position numbers. Parts (d)(ii) and (d)(iii) were generally well attempted, although a number used aspartic acid in (d)(iii) . Part (d)(iv), however, was less well done. Many candidates did not realise that a quaternary ammonium salt was required and even those who did often gave answers containing ethyl groups rather than methyl groups on N.

Q15.

There were very few correct answers to part (a), but part (b) was well answered, although some misread the question here and tried to use benzene-1,2-dicarboxylic acid or tetrachloroethene.

Part (c)(i) was quite well done although many wrong answers included CH_2CH_3OH for ethanol or two moles of water.

In part (d), many candidates missed the +. from the molecular ion or put the . on the radical in the wrong place. Several of those who chose to write a formula for the benzene ring in DEP, rather than use the structure given, lost the mark if they gave C_6H_6 rather than C_6H_4 in the formula for the molecular ion and fragment ion.

A surprising number of candidates wrote a chemical equation or included [H_2O] in the rate equation in part (e)(i). Not many candidates scored both marks in part (e)(ii), with many

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simply referring to more repeats.

Q16.

Part (a) was answered well by two thirds of the candidates. In part (b)(i), half gave a correct structure; many wrong answers showed too many repeating units or included an extra oxygen atom. The type of polymerisation in part (b)(ii) and the required bond in part (c)(i) were both very well known. In part (c)(ii) the answer was required as a displayed formula, ie it must show **all** the bonds. Many candidates have still not realised that all includes the O–H bond. Part (d) was correctly answered by fewer than a fifth of the candidates. Many simply drew 2-aminobutanoic acid rather than its zwitterion. In parts (e)(i) and (e)(ii), many candidates did not recognise that both acid groups in glutamic acid would react. Two thirds of candidates answered part (e)(i) correctly, but parts (e)(ii) and (e)(iii) were found more difficult. In part (f), some candidates explained clearly how column chromatography worked and just under a third gained full marks in this section. Others described paper chromatography or were obviously unfamiliar with the topic.

Q17.

Candidates are able to tackle organic reaction mechanisms with confidence and this question was well answered. The most demanding part was part (a)(iii) in which they had to indicate that the carbon-bromine bond was polar.

Q19.

Part (a)(i) was answered well by almost all candidates. In part (a)(ii) most were able to draw correct structures of the diol and the diacid but only the better candidates were able to name these molecules correctly. Even naming the relatively straightforward butan-2,3-diol caused problems. The dipeptides in part (b) were usually well drawn. In part (c) most candidates were able to draw the structure of a suitable halopropane in part (i), but many found the structure of the nitrile much harder. $CH_3CH_2CH_2CN$ and $CH_3CH_2CH_2NO2$ were common wrong answers. In part (iii), the first two parts were well answered, but relatively few candidates were able to draw the structure of a correct secondary or tertiary amine or a quaternary ammonium salt formed when propylamine reacts with an excess of halopropane.

Q20.

All parts of this question proved to be very accessible to all but the lowest achieving candidates. The most common errors arose from failing to use *concentrated* sulphuric (or phosphoric) acid in part (b)(ii) and from failing to give a clear statement of the advantage which ethanol offers as a fuel.

Q21.

Only the better candidates were able to calculate the number of moles of C_2F_2 and of HC1 correctly. However, if the rest of the answer used correct chemistry, no further marks were lost. The expression for K_c was well known, but there was uncertainty over the use of the volume of the container in the calculation. Many forgot to include it at all and so used a number of moles instead of the concentration in mol dm^{-3}. Some tried to include the number 18.5 dm^3 in the expression for K_c and others tried to convert the volume into m^3. Parts (b) and (c) were well answered even by those who lost marks in the calculation in part (a).

Q22.

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Weaker candidates gained the marks in part (a) but scored few others in this question. In part (b) many attempted to name the dipeptide rather than the amino acid as asked. Similarly the correct structure of the protonated amino acid was given only by the more able candidates; many others attempted to draw the protonated dipeptide. In part (c), the empirical formula was reasonably well answered, but few candidates seemed to understand that the polyester must have been formed from a diacid, so that common answers such as propanoic or butanoic acids could not be correct. The statement that "polyesters and polyamides can be broken down by hydrolysis and are, therefore, biodegradable" appears in the specification. Unfortunately few candidates were able to recall or understand this point.

Q24.

Most candidates were able to draw the structure of the anion required in part (a)(i) and the dipeptide in part (a)(ii), although a common wrong answer in part (ii) was the repeating unit of the polymer. "Hydrogen bonding" was correctly given by most candidates in part (iii) and "addition" polymerisation was well known in part (b)(i). Weaker candidates simply drew hydrocarbon **G** again in part (b)(ii) rather than pent-2-ene and better candidates were able to deduce that a saturated cycloalkane, such as cyclopentane was required in part (iii).

Q26.

While some good answers to part (a) were seen, in general the definitions were poor. Electrophiles were often described as being positive ions or as having a surplus of electrons. Many candidates tried to describe addition simply as 'one molecule/atom adding on to another'. Correct simple definitions based on two molecules joining to form a single molecule were not common and were usually offered by the better candidates. The responses offered for part(b) were quite varied. Many candidates described the induced polarisation of the bromine molecule but fewer identified the high electron density present around the double bond in propene as its cause. Some candidates incorrectly described a process in which a lone pair from bromine was donated to the double bond, or suggested heterolytic fission of the Br-Br bond followed by an electrophilic attack by Br+ on the double bond. Many clear and accurately drawn mechanisms were seen; however, it was not uncommon to see a primary carbocation as the intermediate. Poorly drawn curly arrows, which did not start at a bond/lone pair, or which did not end at a bond/atom, were also quite common. In some cases, candidates showed the bromine molecule with full charges or the intermediate/bromide ion with a partial charge. Curly arrows moving in the wrong direction, e.g. from a bromine atom towards the double bond, were not uncommon. The product was usually correctly named, with the most common errors being the use of 'bromopropane', rather than 'dibromopropane', or quoting the carbon skeleton as 'ethane', 'butane' or 'pentane'. Part (d) was generally well done although a number of candidates described the process as 'additional polymerisation' or as 'condensation'.

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