M1.(a) 2-deoxyribose

1

(b) Base A

If Base B stated, allow 1 mark only for response including hydrogen bonding

1

Top N–H forms hydrogen bonds to lone pair on O of guanine

1

The lone pair of electrons on N bonds to H–N of guanine

1

A lone pair of electrons on O bonds to lower H–N of guanine

Allow all 4 marks for a correct diagram showing the hydrogen bonding

Students could also answer this question using labels on the diagram

1

(c) Allow either of the nitrogen atoms with a lone pair NOT involved in bonding to cytosine

1

(d) Use in very small amounts / target the application to the tumour

1

[7]

M2. (a) $Pt(NH_3)_2Cl_2 + H_2O \rightarrow [Pt(NH_3)_2Cl(H_2O)]^+ + Cl^-$

Correct product

1

Balanced equation

1

(b) (i) Hydrogen bond

1

Oxygen (or nitrogen)

Only score this mark if type of bond is correct

1

(ii) Co-ordinate

1

Nitrogen (or oxygen)

Bond type must be correct to score this mark but allow M2 if bond is covalent

1

(c) Killing them or causing damage (medical side effects)

Allow any correct side effect (e.g. hair loss)
Allow kills healthy (or normal) cells

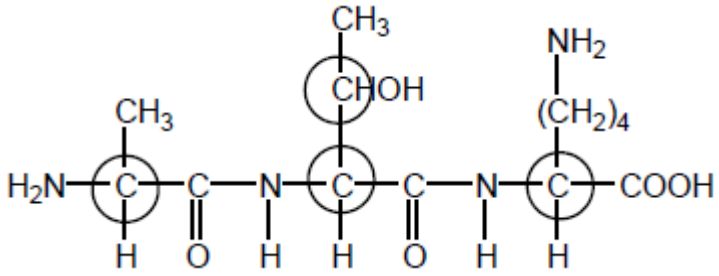
1

May attach to DNA in normal cells

1

[8]

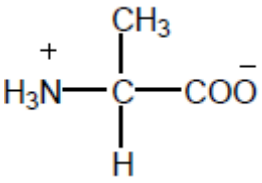
M1.(a) (i)



These four only

1

(ii)



Allow − NH_3^+ and $^+NH_3^-$

1

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

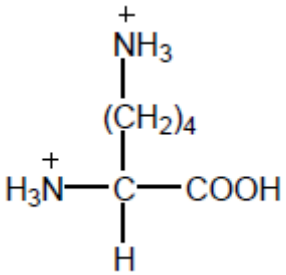
Ignore 1 in butan-1-oic acid

Do not penalise commas or missing hyphens

Penalise other numbers

1

(iv)



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*

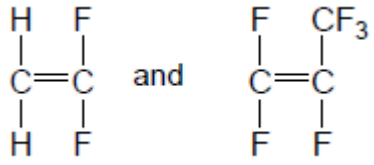
1

(c) (i) Addition

Not additional

1

(ii)

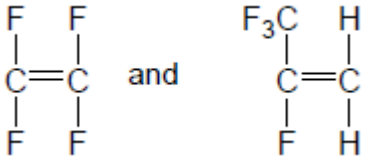


Allow monomers drawn either way round

Allow bond to F in CF_3

1

OR



1 for each structure within each pair

1

(d) c

If wrong, CE = 0

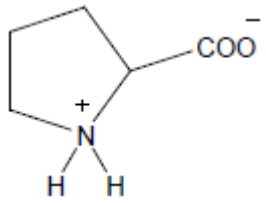
1

C-C or C-F bonds too strong

1

[11]

M2.(a) (i)



Allow CO_2^- and NH_2^+

1

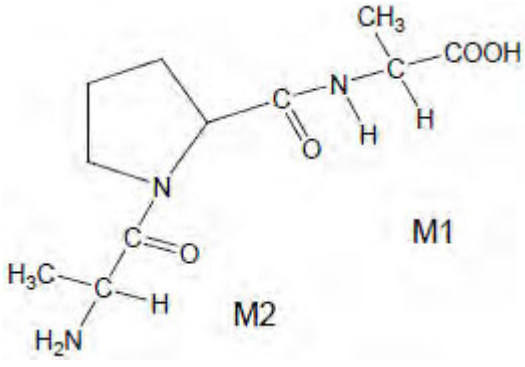
(ii) NOTE − **Two** marks for this clip

M1 for alanine section bonded through N

M2 for alanine section bonded through C

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

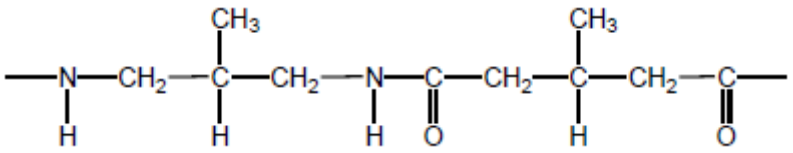
1

(ii) 4-amino-3-methylbutanoic acid

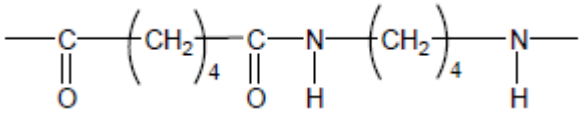
Ignore commas, spaces or missing hyphens

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

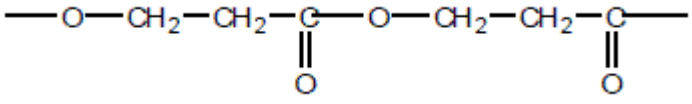
[7]

M3. (a) 3-hydroxypropanoic acid

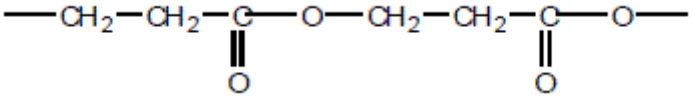
allow 3-hydroxypropionic acid
must be correct spelling

1

(b) (i) must show trailing bonds



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



not allow dimer
allow –O–CH₂CH₂COOCH₂CH₂CO–
or –CH₂CH₂COOCH₂CH₂COO–
ignore ( ) or n
NB answer has a total of 6 carbons and 4 oxygens

1

(ii) condensation (polymerisation)

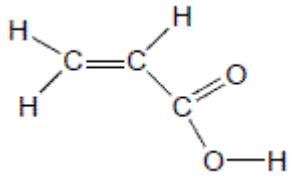
Allow close spelling

1

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

1

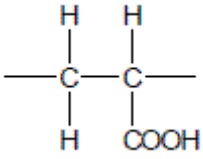
(ii)



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

1

(iii) must show trailing bonds

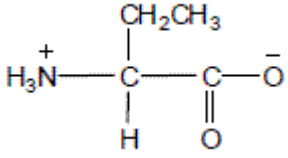


allow polyalkene conseq on their c(ii)

ignore n

1

(d)

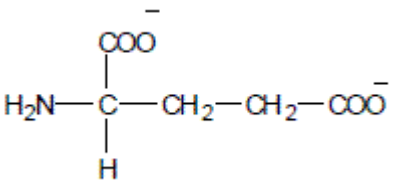


allow NH_3^+—

allow COO^-

1

(e) (i)



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

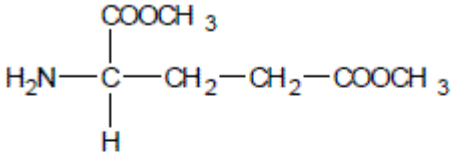
NB two carboxylate groups

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

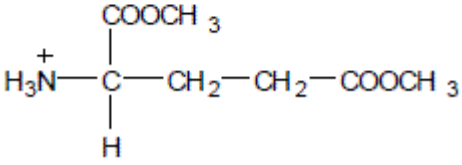
allow NH_2–

1

(ii)



OR



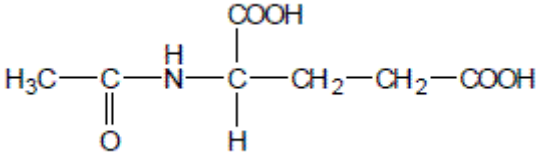
In (e), do not penalise a slip in the number of carbons in the -CH_2CH_2- chain, but all must be bonded correctly

NB two ester groups

allow NH_2– or $^+NH_3$–

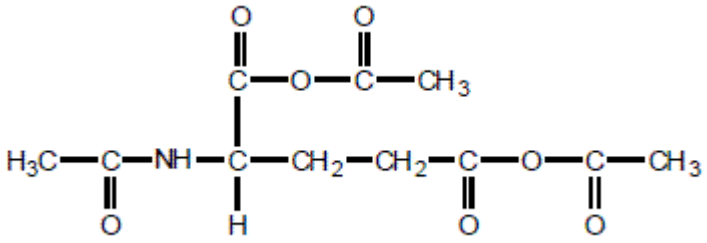
1

(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 moving or mobile

1

M2 stationary phase or solid or alumina/silica/resin

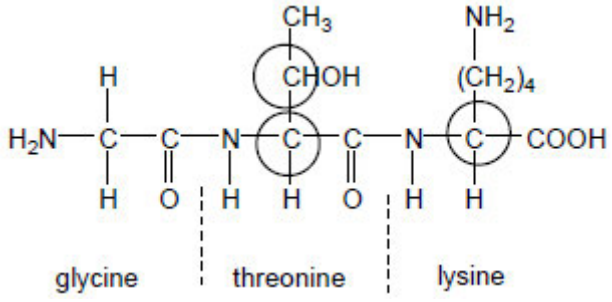
1

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

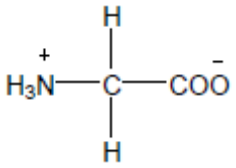
[13]

M4.(a)



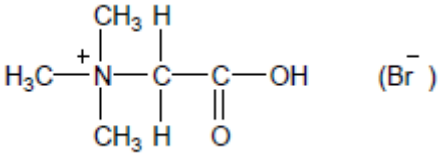
1

(b)

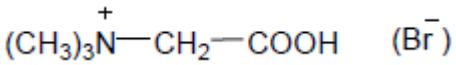


1

(c)



Allow

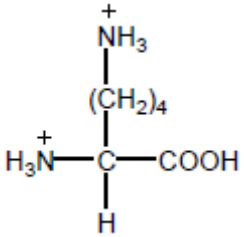


1

(d) 2-amino-3-hydroxybutanoic acid

1

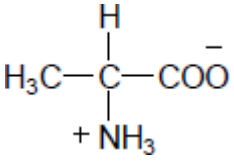
(e)



1

[5]

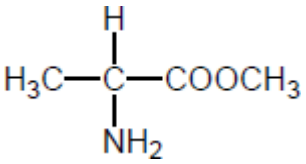
M5.(a)



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

1

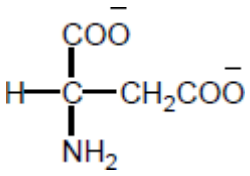
(b)



Allow protonated form, i.e. $-NH_3^+$ or $^+NH_3-$

1

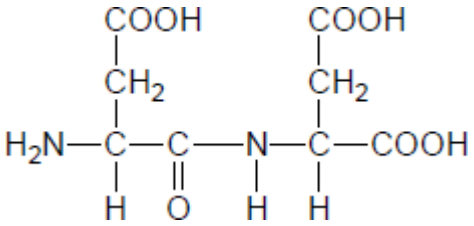
(c)



Allow – CO_2^-

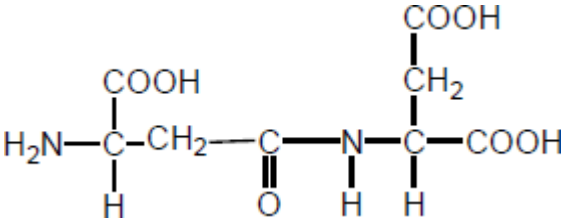
1

(d)



Allow zwitterion with any COO^-

Allow use of "wrong" COOH



1

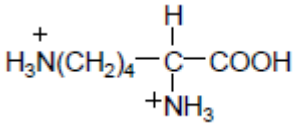
[4]

M6.(a) <u>2,6-diaminohexanoic acid</u>

Ignore additional , or – or spaces.

1

(b) (i)



$(2Cl^-)$

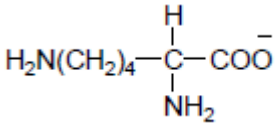
NB both N must be protonated.

Allow $-NH_3^+$ allow CO_2H Allow $-^+H_3N$.

Penalise – C_4H_8 – here.

1

(ii)



(Na^+)

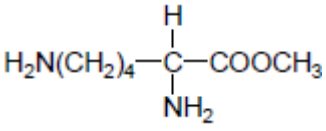
Allow CO_2^-.

Allow $-H_2N$.

Allow –COONa but penalise O–Na bond shown.

1

(iii)

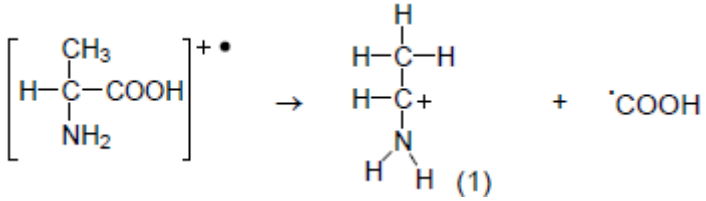


Allow CO_2CH_3.

Allow $-NH_3^+$ or $-H_2N$.

1

(c)



1 for <u>displayed formula</u> of fragment ion.

1 for molecular ion of alanine AND radical.

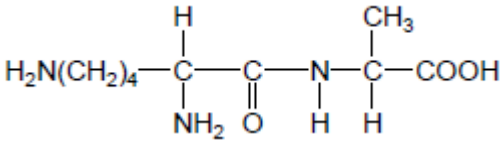
Allow molecular ion without brackets and fragment ion in brackets with outside +.

Allow dot anywhere on radical.

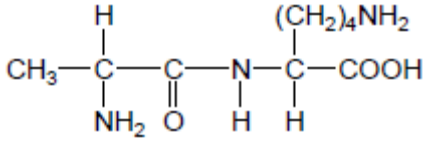
Allow $[C_3H_7NO_2]^{+\bullet}$ for molecular ion.

2

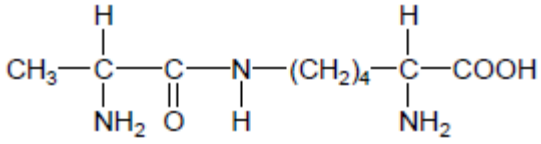
(d)



OR



OR



Dipeptide, not repeating unit /.

Allow CO_2H Allow $–H_2N$.

Allow –CONH–.

1

(e) M1 In acid lysine has double positive or more positive charge

1

M2 sticks (Lysine ion) has greater affinity / greater attraction / adheres better / better to polar / stationary phase

M2 only scores after a correct M1.

Ignore greater retention time.

1

[9]

M7.(a) **Wear plastic gloves:**

Essential – to prevent contamination from the hands to the plate

1

Add developing solvent to a depth of not more than 1 cm^3:

Essential – if the solvent is too deep it will dissolve the mixture from the plate

1

Allow the solvent to rise up the plate to the top:

Not essential – the R_f value can be calculated if the solvent front does not reach the top of the plate

1

Allow the plate to dry in a fume cupboard:

Essential – the solvent is toxic

Allow hazardous

1

(b) Spray with developing agent or use UV

1

Measure distances from initial pencil line to the spots (*x*)

1

Measure distance from initial pencil line to solvent front line (*y*)

1

R_f value = *x* / *y*

1

(c) Amino acids have different polarities

1

Therefore, have different retention on the stationary phase or different solubility in the developing solvent

1

[10]

M1.(a) Heating <u>speeds up</u> (hydrolysis / breaking of peptide bonds)

OR forms non-sweet (amino acids)

1

(b) (2-)aminobutan**<u>e</u>**dioic acid OR

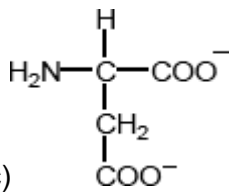
2 not necessary but penalise other numbers at start

(2-)aminobutan**<u>e</u>**(-1,4-)dioic acid

1,4 not necessary but penalise other numbers and 1,4 must be in correct place (QoL)

1

(c)

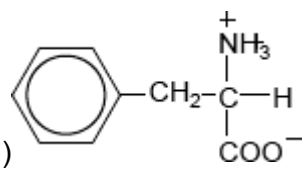


allow –CO_2^-

allow NH_2–

1

(d)



allow –CO_2^-

allow +NH_3–

don't penalize position of + on NH_3

1

(e) (i) **M1** Compounds/molecules with same <u>structural formula</u>

Not just structure

1

M2 But with <u>bonds/atoms/groups</u> arranged differently <u>in space</u> or <u>in 3D</u>

Allow –with different <u>spatial</u> arrangement of <u>atom/bond/group</u>

1

Independent marks

(ii) (Plane) polarised light

1

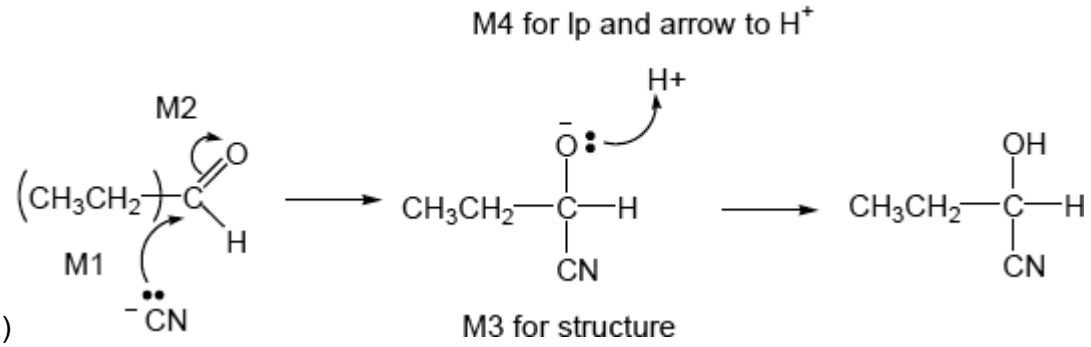
Rotated in opposite directions

Not bent or turned or twisted; not different directions (QoL)

1

[8]

M2.(a) nucleophilic addition



- *allow :CN–*
- *M2 not allowed independent of M1, but*
- *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 C_2H_5*
- *M1 and M4 for lp and curly arrow*

1

4

(b) *2-bromobutanenitrile*

Allow 2-bromobutane-1-nitrile

1

(c) ***M1*** *ammonia or NH_3*

Ignore temp or pressure

1

M2 *excess (ammonia)* *excess tied to NH_3 and may score in M1 unless contradicted*

Ignore concentrated or sealed container, Acid loses conditions mark

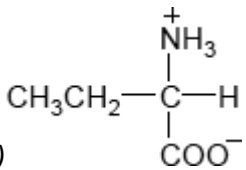
1

M3 *nucleophilic substitution*

Allow close spelling

1

(d) *(i)*



Allow C_2H_5

Allow $–CO_2^-$

Allow $^+NH_3–$

Don't penalize position of + on NH_3

1

(ii) ***M1*** *electrostatic <u>forces between ions</u> in **X*** ***QOL***

Allow ionic bonding.

1

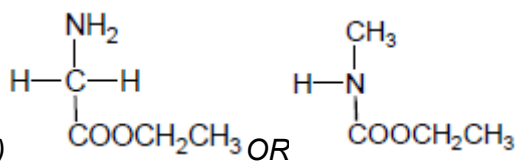
Marks independent

M2 *(stronger than) <u>hydrogen bonding</u> between $CH_3CH_2CH(OH)COOH$*

CE *mention of molecules of **X** or inter molecular forces between **X** loses both marks*

1

(e) *(i)*



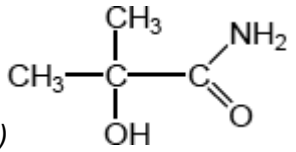
OR

Isomer of $C_4H_9NO_2$

Allow NH_2–

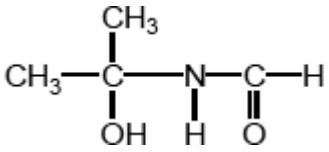
1

(ii)



Isomer of $C_4H_9NO_2$ allow NH_2–

Allow

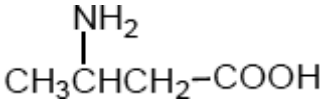


1

(iii) *$H_2N–CH_2CH_2CH_2–COOH$ or $H_2N–(CH_2)_{3–COOH}$*

Isomer of $C_4H_9NO_2$ allow NH_2–

OR

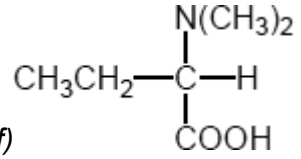


*Do **not** allow $–C_3H_6$-*

*Beware – do not credit **X** itself*

1

(f)



*Answer has 6 carbons so **NOT** isomer of **X***

Allow C_2H_5

Must have bond from C to N not to methyl group

1

[16]

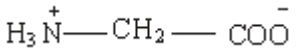
M3. (a) *polyamide or nylon (2,4)*

(allow nylon without numbers but if numbers are present they must be correct)

1

condensation

1

(b) 

1

(c) *ionic bonding in aminoethanoic acid*

(can only score if includes that aminoethanoic is ionic)

1

stronger attractions than Hydrogen bonding in hydroxyethanoic acid

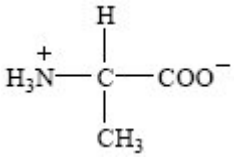
(e.g. stronger Hydrogen bonding in aminoethanoic acid scores 0)

(mention of electrostatic forces between molecules scores 0)

1

[5]

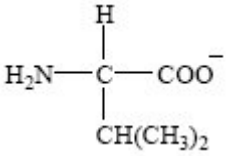
M4. *(a)* *(i)*



allow $-CO_2^-$
allow $^+NH_3-$
don't penalize position of + on NH_3

1

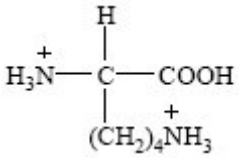
(ii)



allow $-CO_2^-$
allow NH_2-
allow C_3H_7

1

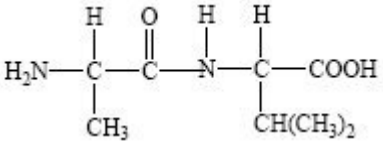
(iii)



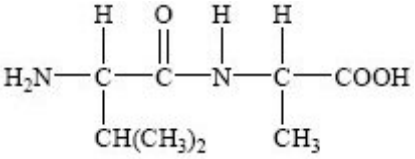
allow –CO_2H
allow $^+NH_3$–
don't penalize position of + on NH_3

1

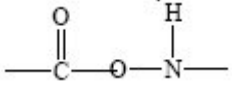
(b)



1



allow –CO_2H
allow NH_2–
allow C_3H_7
allow as zwitterions
if error in peptide link e.g.



if twice, penalise both times
not polymers
if wrong amino acid in both can score Max 1

1

(c) chromatography or electrophoresis

ignore qualification to chromatography

1

[6]

M5. *(a) (i) hydrolysis*

not hydration

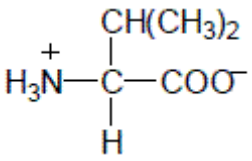
1

(ii) *2-aminopropanoic acid*

ignore alanine
QoL

1

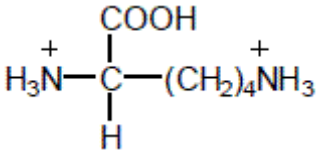
(iii)



allow $-CO_2^-$
allow $^+NH_3-$
don't penalize position of + on NH_3

1

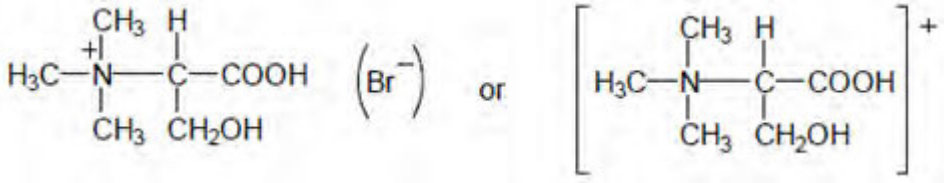
(iv)



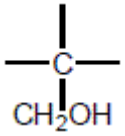
allow $-CO_2^-$
allow $^+NH_3-$
don't penalize position of + on NH_3

1

(b) *(i)*



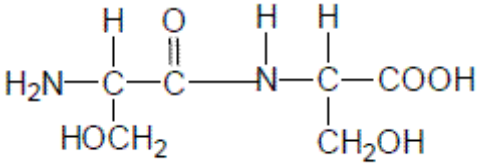
allow $-CO_2H$



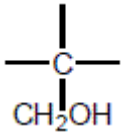
allow limit as
+ on N or outside [ ]

1

(ii)



allow –CO_2H allow –CONH– or –COHN–
allow NH_2–

allow limit as 

1

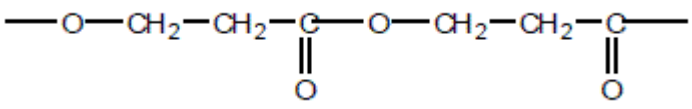
[6]

M6. *(a)* *3-hydroxypropanoic acid*

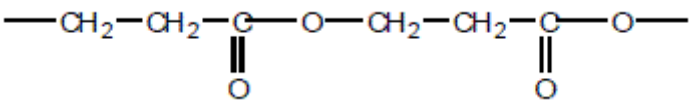
allow 3-hydroxypropionic acid
must be correct spelling

1

(b) *(i)* *must show trailing bonds*



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)*

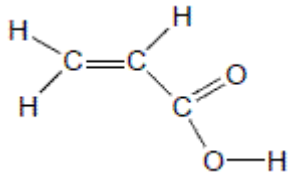
Allow close spelling

1

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

1

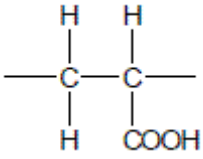
(ii)



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

1

(iii) *must show trailing bonds*

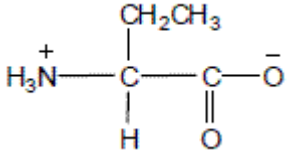


allow polyalkene conseq on their c(ii)

ignore n

1

(d)

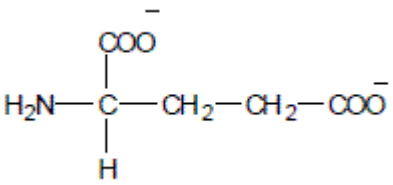


allow NH_3^+—

allow COO^-

1

(e) (i)



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

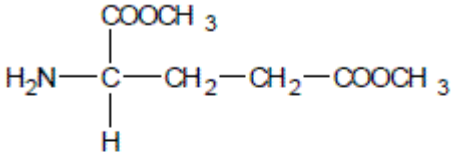
NB two carboxylate groups

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

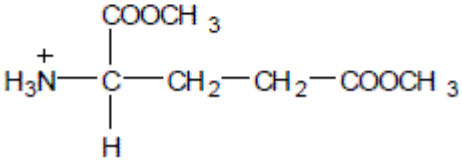
allow NH_2–

1

(ii)



OR



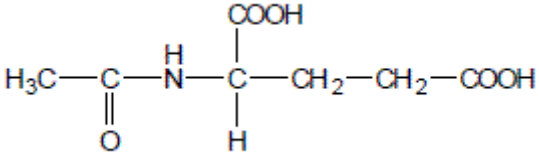
In (e), do not penalise a slip in the number of carbons in the -CH_2CH_2- chain, but all must be bonded correctly

NB two ester groups

allow NH_2– or $^+NH_3$–

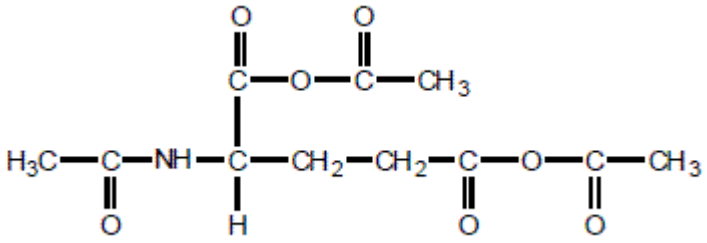
1

(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>*

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]

M1.(a) 2-deoxyribose

1

(b) Base A

If Base B stated, allow 1 mark only for response including hydrogen bonding

1

Top N–H forms hydrogen bonds to lone pair on O of guanine

1

The lone pair of electrons on N bonds to H–N of guanine

1

A lone pair of electrons on O bonds to lower H–N of guanine

Allow all 4 marks for a correct diagram showing the hydrogen bonding

Students could also answer this question using labels on the diagram

1

(c) Allow either of the nitrogen atoms with a lone pair NOT involved in bonding to cytosine

1

(d) Use in very small amounts / target the application to the tumour

1

[7]

M1.C

[1]

M1.(a) Secondary

1

(b) Nitrogen and oxygen are very electronegative

1

Therefore, C=O and N–H are polar

1

Which results in the formation of a hydrogen bond between O and H

1

In which a lone pair of electrons on an oxygen atom is strongly attracted to the δ+H

1

[5]

M2. (a) (i) hydrolysis

not hydration

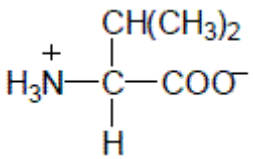
1

(ii) 2-aminopropanoic acid

ignore alanine
QoL

1

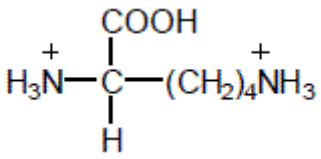
(iii)



allow $-CO_2^-$
allow $^+NH_3-$
don't penalize position of + on NH_3

1

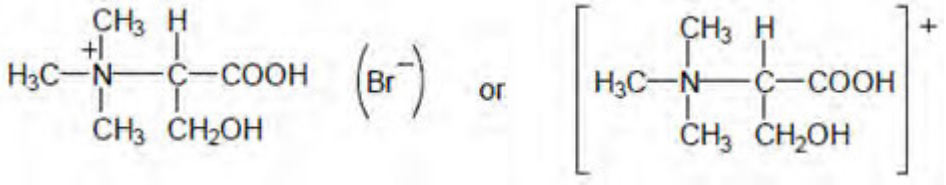
(iv)



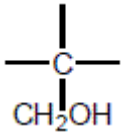
allow $-CO_2^-$
allow $^+NH_3-$
don't penalize position of + on NH_3

1

(b) (i)



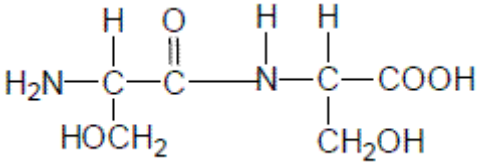
allow $-CO_2H$



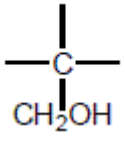
allow limit as
+ on N or outside [ ]

1

(ii)



allow $-CO_2H$ allow –CONH– or –COHN–
allow NH_2-

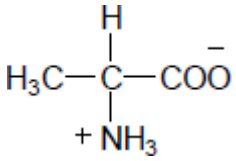


allow limit as

1

[6]

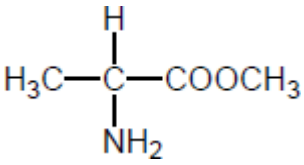
M3.(a)



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

1

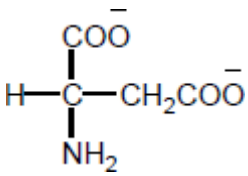
(b)



Allow protonated form, i.e. $-NH_3^+$ or $^+NH_3-$

1

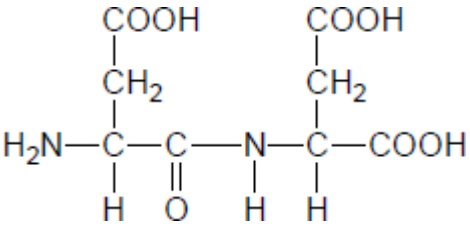
(c)



Allow – CO_2^-

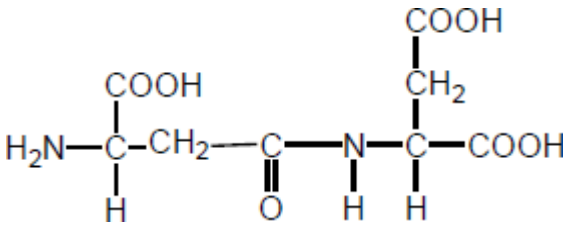
1

(d)



Allow zwitterion with any COO^-

Allow use of "wrong" COOH



1

[4]

M4.(a) Heating <u>speeds up</u> (hydrolysis / breaking of peptide bonds)

OR forms non-sweet (amino acids)

1

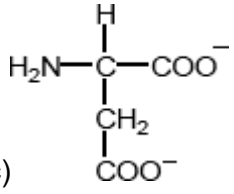
(b) (2-)aminobutan**<u>e</u>**dioic acid OR

2 not necessary but penalise other numbers at start

(2-)aminobutan**<u>e</u>**(-1,4-)dioic acid

1,4 not necessary but penalise other numbers and 1,4 must be in correct place (QoL)

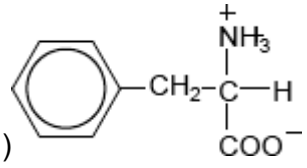
1

(c) 

allow $-CO_2^-$

allow NH_2-

1

(d) 

allow $-CO_2^-$

allow $+NH_3-$

don't penalize position of + on NH_3

1

(e) (i) **M1** Compounds/molecules with same <u>structural formula</u>

Not just structure

1

M2 But with <u>bonds/atoms/groups</u> arranged differently <u>in space</u> or <u>in 3D</u>

Allow –with different <u>spatial</u> arrangement of <u>atom/bond/group</u>

1

Independent marks

(ii) (Plane) polarised light

1

<u>Rotated</u> in opposite directions

Not bent or turned or twisted; not different directions (QoL)

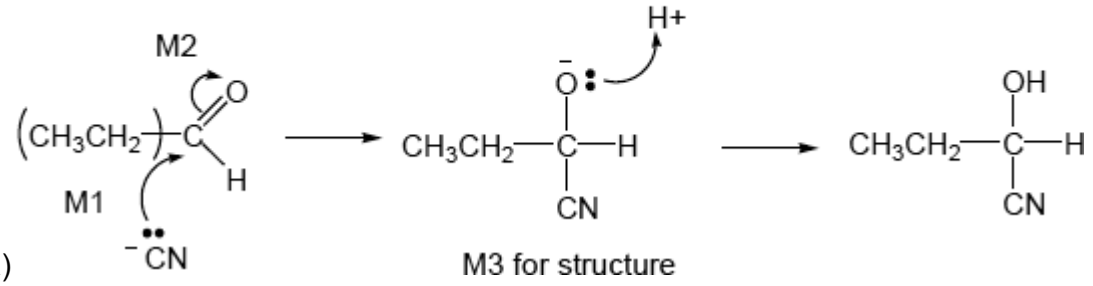
1

[8]

M5.(a)

nucleophilic addition

M4 for lp and arrow to H^+



M3 for structure

- *allow :CN–*
- *M2 not allowed independent of M1, but*
- *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 C_2H_5*
- *M1 and M4 for lp and curly arrow*

1

4

(b) *2-bromobutanenitrile*

Allow 2-bromobutane-1-nitrile

1

(c) ***M1*** *ammonia or NH_3*

Ignore temp or pressure

1

M2 *excess (ammonia)* *excess tied to NH_3 and may score in M1 unless contradicted*

Ignore concentrated or sealed container, Acid loses conditions mark

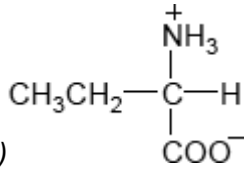
1

M3 *nucleophilic substitution*

Allow close spelling

1

(d) (i)



Allow C_2H_5

Allow $–CO_2^-$

Allow $^+NH_3–$

Don't penalize position of + on NH_3

1

(ii) ***M1*** *electrostatic <u>forces between ions</u> in **X*** ***QOL***

Allow ionic bonding.

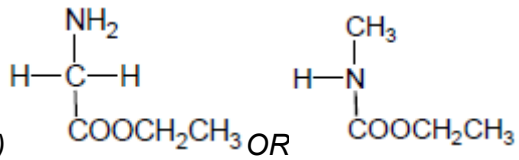
1

Marks independent

M2 *(stronger than) <u>hydrogen bonding</u> between $CH_3CH_2CH(OH)COOH$*

CE *mention of molecules of **X** or inter molecular forces between **X** loses both marks*

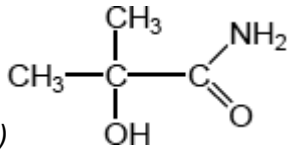
1

(e) (i)  *OR*

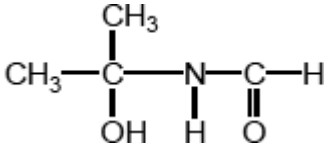
Isomer of $C_4H_9NO_2$

Allow NH_2–

1

(ii) 

Isomer of $C_4H_9NO_2$ allow NH_2–

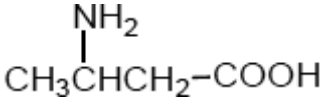
Allow 

1

(iii) *$H_2N–CH_2CH_2CH_2–COOH$ or $H_2N–(CH_2)_{3–COOH}$*

Isomer of $C_4H_9NO_2$ allow NH_2–

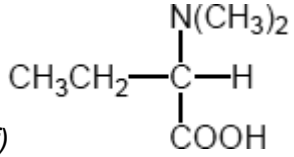
OR



*Do **not** allow $–C_3H_6-$*

*Beware – do not credit **X** itself*

1

(f) 

*Answer has 6 carbons so **NOT** isomer of **X***

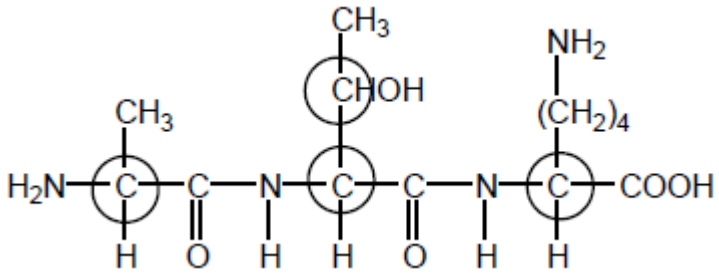
Allow C_2H_5

Must have bond from C to N not to methyl group

1

[16]

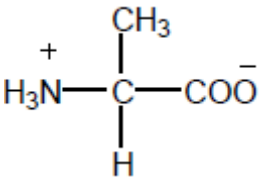
M6.*(a)* *(i)*



These four only

1

(ii)



Allow − NH_3^+ and $^+NH_3^-$

1

(iii) *2-amino-3-hydroxybutanoic acid*

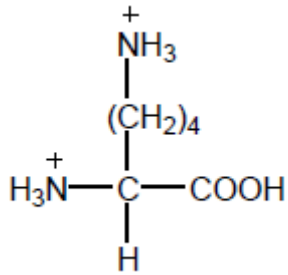
Ignore 1 in butan-1-oic acid

Do not penalise commas or missing hyphens

Penalise other numbers

1

(iv)



Allow $-NH_3^+$ 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*

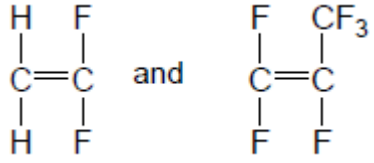
1

(c) (i) *Addition*

Not additional

1

(ii)

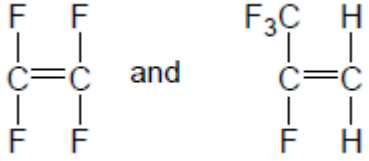


Allow monomers drawn either way round

Allow bond to F in CF_3

1

OR



1 for each structure within each pair

1

(d) *c*

If wrong, CE = 0

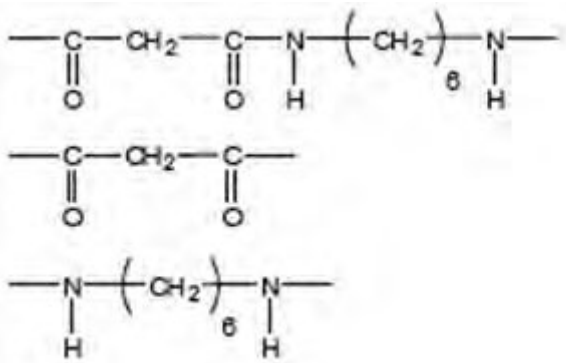
1

C-C or C-F bonds too strong

1

[11]

M1. (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

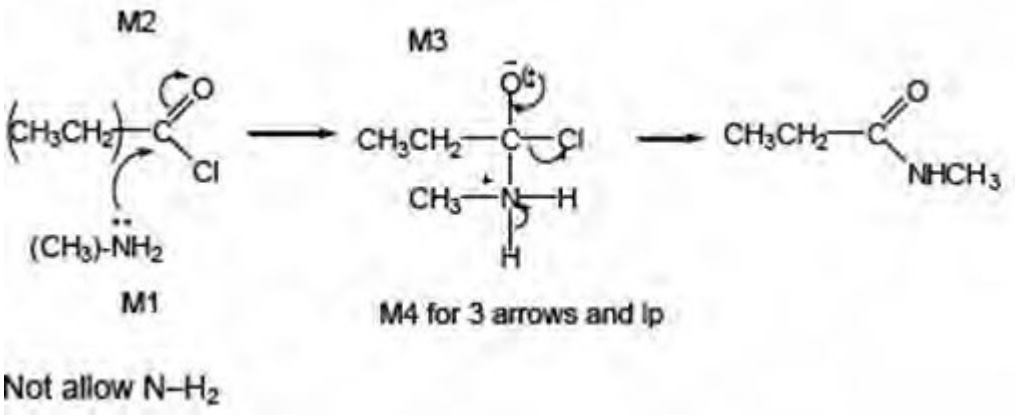
1

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+*

*+ 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

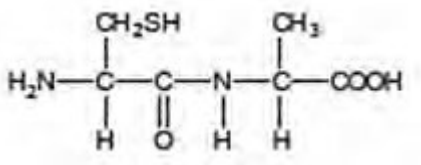
4

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

Not N-methylpropaneamide

1

(c)



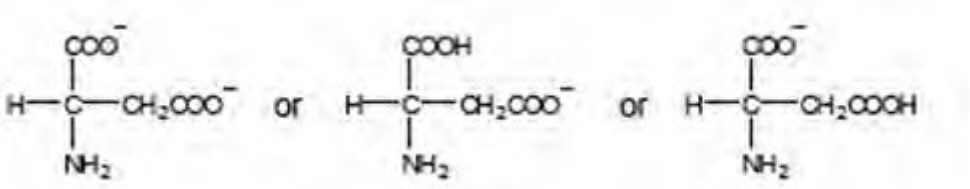
Allow –CONH– or –COHN–

1

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

1

(ii)



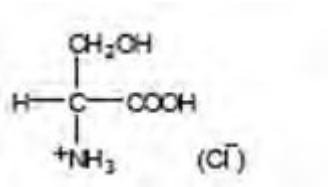
Must be salts of aspartic acid

allow $–CO_2^-$

allow $NH_2–$

1

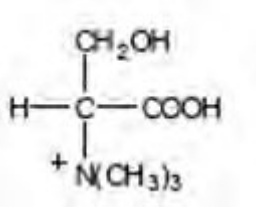
(iii) Penalise use of aspartic acid once in d(iii) and d(iv)



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)



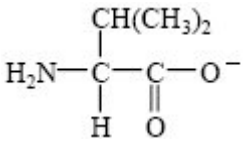
(Br^-)

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

1

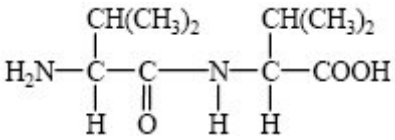
[16]

M2. (a) (i)



1

(ii)



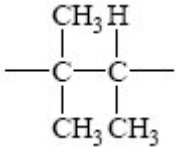
1

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

do not penalise any error twice.

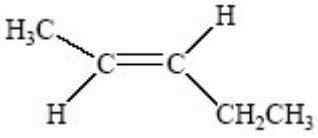
1

(b) (i)



1

(ii)

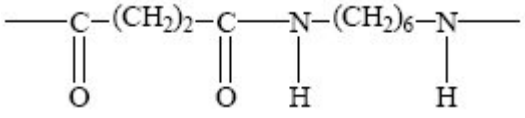


1

(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

polyamide is hydrolysed (or undergoes hydrolysis)
to form acid salt and alcohol QWC

1

(ii) e.g combustion

1

heat energy produced

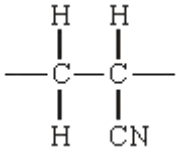
1

toxic gases produced

1

[14]

M3. (a) (i)



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

1

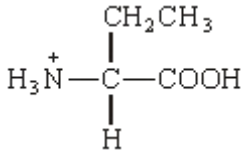
(ii) Addition or radical

1

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

1

(ii)

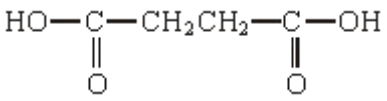


1

(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]

M4. (a) (i) $CH_3CH=CHCH_3$

1

Addition or radical (**QoL**)

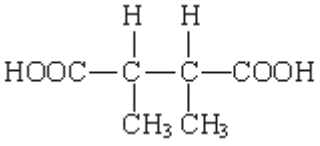
1

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

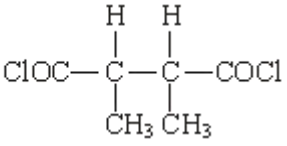
1

butan(e)–2,3–diol or 2,3–butan(e)diol

1



allow



1

2,3–dimethylbutan(e)dioic acid 2,3–dimethylbutan(e)dioyl chloride

ignore –1,4–

1

condensation (**QoL**)

1

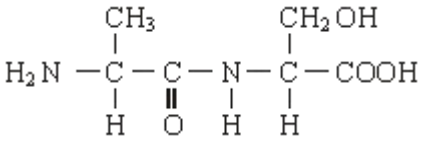
(iii) NaOH or HCl etc or Na_2CO_3

Allow conc sulphuric/nitric

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

1

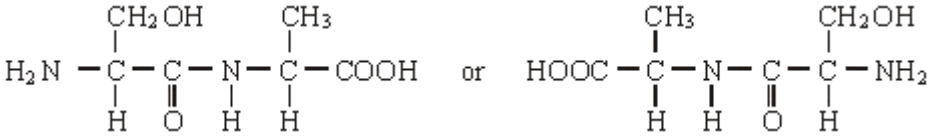
(b) Structure 1



Allow –CONH– and –COHN–
Allow zwitterions
NOT polypeptides/repeating units

1

Structure 2 either of



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]