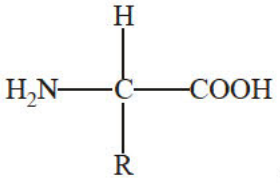
F324: Rings, Polymers & Analysis
4.2.1 – Amino Acids & Chirality MARK SCHEME

1. (i)



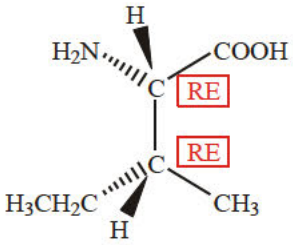
✓

ALLOW *$RCH(NH_2)COOH$ any order for R, NH_2 and COOH*
but C must be next to H 'CH' must be shown
ALLOW *CO_2H*
brackets around NH_2 are ***not*** *essential*
ALLOW *structure*

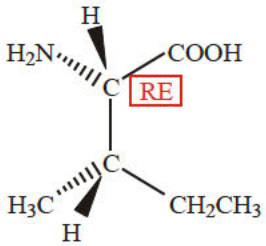
1

(ii) must attempt 3D

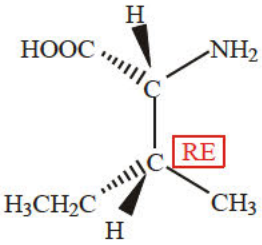
use RE symbol in the "tools" to denote whether or not each chiral C is a reflection of the one given in the question



both chiral Cs
are mirror images



top chiral C only
is a mirror image



bottom chiral C only
is a mirror image

*each chiral C must have 2 — bonds, 1 wedge bond (****IGNORE*** *shading) & 1 dash bond (****IGNORE*** *wedge)*
check the clockwise orientation of each C. For each C start with the H and if on the:

- *top C the H is followed by COOH it is not a mirror image. If it is a mirror image annotate using RE.*
- *bottom C the H is followed by CH_3 it is not a mirror image. If it is a mirror image annotate using RE.*

the four groups can be attached in any order. If the molecule is drawn upside down – clockwise becomes anti-clockwise.

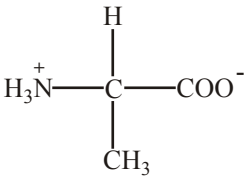
MUST *check that the drawn structure is non-superimposable irrespective of the orientation or the way it has been drawn.*

IGNORE *bond linkage for all groups*

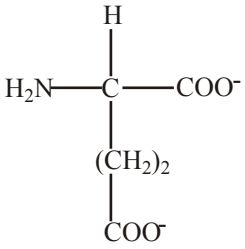
3

[4]

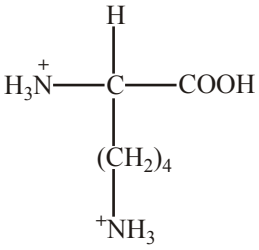
2.



alanine at pH = 6.0 ✓



glutamic acid at pH = 10 ✓



lysine at pH = 2.0 ✓

ALLOW CO_2^-

ALLOW NH_3^+

If NH_3 fully displayed ***ALLOW*** *+ charge on N or H*

If COO fully displayed ***ALLOW*** *– charge on O only*

[3]

3. valine–glycine–leucine ✓

ALLOW *val–gly–leu*

DO NOT ALLOW *structures*

[1]

4. (i) one amide link shown correctly **(1)**
glycine and phenylalanine parts shown correctly **(1)**
proline linked correctly **(1)** 3

(ii) 6 **(1)** 1

(iii) gas/liquid chromatograph separates the tripeptides **(1)**
mass spectrometer produces a distinctive fragmentation pattern **(1)**
identification by computer using a spectral database **(1)** 3

[7]

5. General formula of an α-amino acid

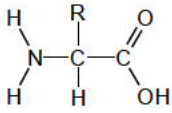
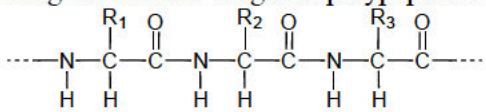
$RCH(NH_2)COOH$ /  **(1)**

Diagram to show length of polypeptide / repeat unit – eg



with:

displayed peptide bond **(1)**

correct structure with a minimum of two amino acids joined (can be scored by a dipeptide) **(1)**

idea of polymerisation shown by 'end bonds' **(1)**

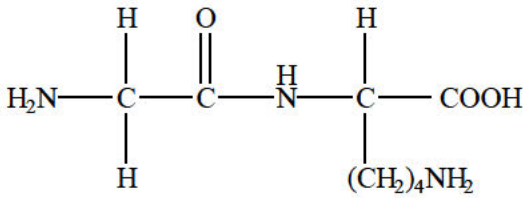
loss of water **(1)**

relate variety to different R groups / sequence of amino acids **(1)** AW 7

Quality of written communication:
correct organisation and use of **both** of the terms:
condensation polymer(isation) and peptide bond/link **(1)** 1

[8]

6.



(1) for CONH and **(1)** for rest. Accept reverse order. 2

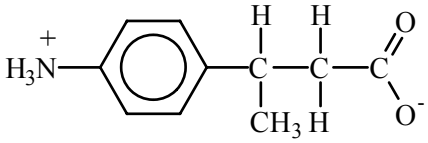
[2]

7. (a) (i) is an amine and a carboxylic acid /
contains both NH2 and COOH functional groups **(1) AW** 1

(ii) $RCH(NH_2)COOH$ **(1)**

Does not fit the formula because NH_2 and COOH are not attached to the same carbon **(1) AW** 2

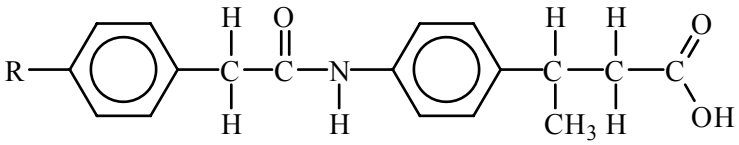
(b) (i)



(1) 1

(ii) $-COO^-$ becomes $-COOH$ **(1)**
(rest of structure unaffected)
(allow ecf on rest of the structure) 1

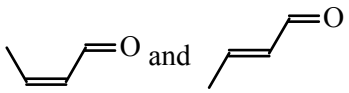
(c)



displayed peptide bond **(1)**
rest of the structure also correct **(1)**
(allow full marks for a correct anhydride structure) 2

[7]

8.

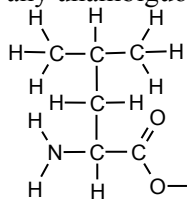
 and

at least one correct skeletal formula **(1)**
correct *cis* and *trans* isomers of but-2-enal **(1)** 2

[2]

9. (a) (i) $RCH(NH_2)COOH$ **(1)** 1
allow groups R, CH, NH_2, COOH in any order$_2$

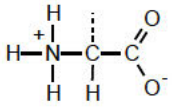
(ii) any unambiguous structure, e.g.:



(1) 1

(b) (i) molecule/ion/'it' has both + and – charges 1

(ii) description or diagram to show proton/H^+ transfer from COOH to NH_2 **(1)**



(1) 2

***NOT** just 'hydrogen' transfer*

(c) (i) heat/warm/reflux **(1)**

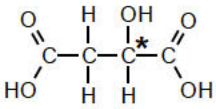
named strong acid/base
an enzyme (which need not be named) **(1)** 2

***NOT** conc HNO_3 or conc H_2SO_4*

(ii) hydrolysis **(1)** 1

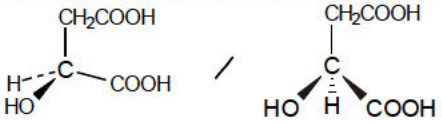
[8]

10. (i)



(1) 1

(ii) structure with correct use of at least two 3-D bonds **(1)** – e.g.



1

allow ecf if lactic acid is labelled in (i)

***NOT** if all four bond angles at 90°*

[2]

11. (a) alkene / C=C double bond
(primary) alcohol / hydroxy(l) **(1)** 1

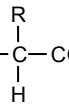
(b) (i) molecules with the same structure / order of bonds … but different arrangements in space / 3-D arrangment **(1)** 1

(ii) cis-trans / geometric **(1)** 1

(iii) the double bond does not rotate **(1)** 1

(iv) same groups at one end / need different groups at both ends of the C=C **(1) AW** 1

[5]

12. (a) (i) $H_2NCHRCOOH$ /  **(1)** 1

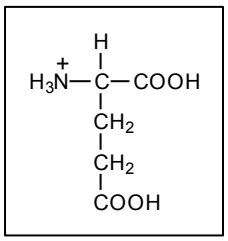
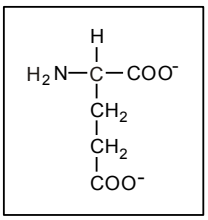
allow R CH NH_2 and COOH in any order

(ii) they both have the group / or in words **(1)**

NOT just "they both have NH_2 and COOH"

R group is H in glycine and CH_2CH_2COOH in glutamic acid **(1)** 2

(b)

	$-NH_3^+$ **(1)** -COOH and side chain unaffected **(1)**		one $-COO^-$ **(1)** both $-COO^-$ **(1)** H_2N- and rest of molecule **(1)**

5

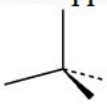
(c) **glutamic acid/molecule with optical isomers …**

… is chiral **(1)**

… has four different / distinguishable groups attached to a carbon **(1)**
NOT just "different atoms"

… the mirror images/isomers cannot be superimposed **AW (1)**

one diagram showing **two** 3-D bonds not opposite each other,
and not with angles looking like 90° **(1)**



3-D diagram of the other isomer (allow ecf on one 3-D error) **(1)**

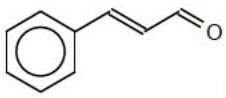
all groups correctly connected for glutamic acid in both diagrams **(1)**

glycine
only has three different groups / two groups are the same /
3-D diagram used to show symmetry **(1)** 8

quality of written communication
for correct use and organisation of at least **one** technical term:
*(in the correct place), non-superimposable, enantiomer, stereoisomer(ism), tetrahedral, assymetric **(1)**

[16]

13. (a)



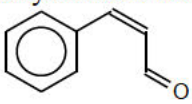
(1) 1

(b) C=C double bond does not rotate **(1)**

two different groups on each carbon (of the C=C) **AW (1)** 2
***NOT** on "each side" of the C=C*

i. trans because H / groups are on opposite sides AW **(1)** 1

ii. any formula that shows the H on the same side – eg



(1) 1

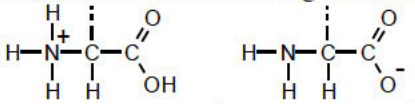
[5]

14. (i) water / evidence of a solution in water – eg
(aq), 'dil' ,'6M' or ' conc' for HC*l* **(1)**
NOT conc HNO_3
or conc H_2SO_4

a named strong acid or alkali (heated under) reflux /
a suitable enzyme at around 37°C **(1)** 2

(ii) amino acids **(1)** 1

(iii) correct structure for one of the amino acids **(1)**
correct ionic form for reagent used in a(i) – eg



/ **(1)** 2

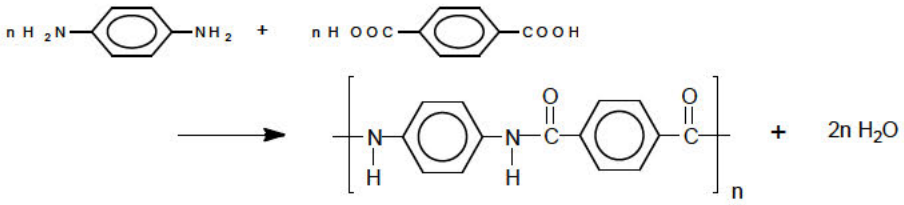
(iv) reaction with water to split/break down the compound **(1)**

peptide bond in the compound is broken / diagram to show AW **(1)** 2

[7]

15. (i) eg fire resistant / bullet proof clothing / cycle tyres / tennis rackets **(1)** 1
allow any use where a tough flexible material is needed

(ii) <u>condensation</u> (polymerisation) **(1)**



structure of benzene-1,4-dicarboxylic acid **(1)**

amide /peptide bond displayed **(1)**

repeat unit of correct polymer indicated **(1)**

formula of water shown as the product in an equation **(1)** 5

[6]