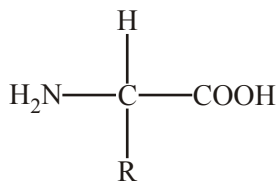


# F324: Rings, Polymers & Analysis

## 4.2.1 – Amino Acids & Chirality MARK SCHEME

1. (i)



✓

**ALLOW**  $\text{RCH}(\text{NH}_2)\text{COOH}$  any order for R,  $\text{NH}_2$  and  $\text{COOH}$

but C must be next to H 'CH' must be shown

**ALLOW**  $\text{CO}_2\text{H}$

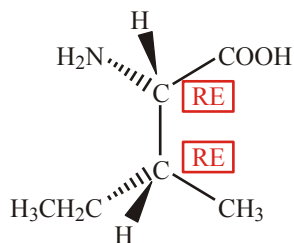
brackets around  $\text{NH}_2$  are **not** essential

**ALLOW** structure

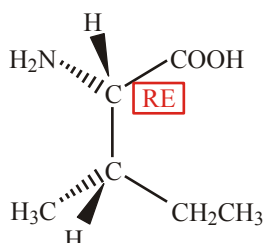
1

(ii) must attempt 3D

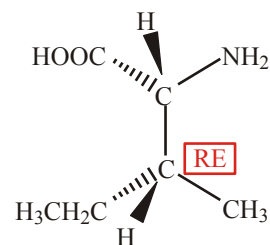
use RE symbol in the “tools” to denote whether or not each chiral C is a reflection of the one given in the question



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  $\text{CH}_3$  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.

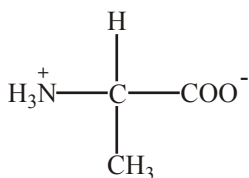
**MUST** check that the drawn structure is non-superimposable irrespective of the orientation or the way it has been drawn.

**IGNORE** bond linkage for all groups

3

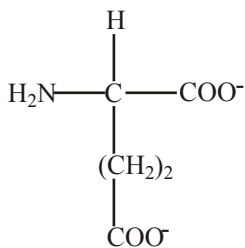
[4]

2.



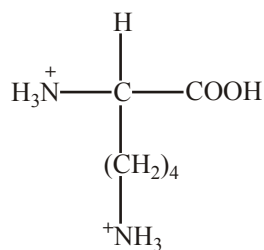
alanine at pH = 6.0

✓



glutamic acid at pH = 10

✓



lysine at pH = 2.0

✓

**ALLOW**  $\text{CO}_2^-$

**ALLOW**  $\text{NH}_3^+$

If  $\text{NH}_3$  fully displayed **ALLOW** + charge on N or H

If  $\text{COO}$  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  $\alpha$ -amino acid

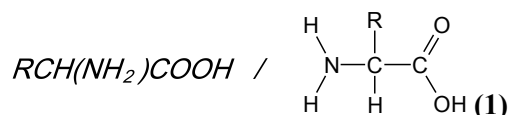
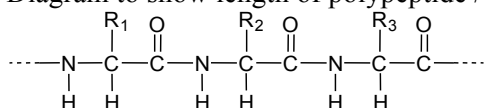


Diagram to show length of polypeptide / repeat unit – eg



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:**

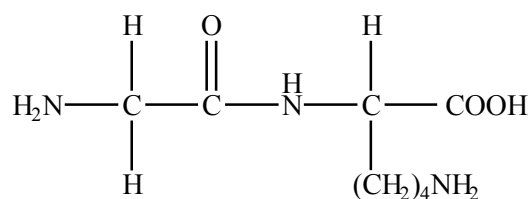
correct organisation and use of **both** of the terms:

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 NH<sub>2</sub> and COOH functional groups (1) AW

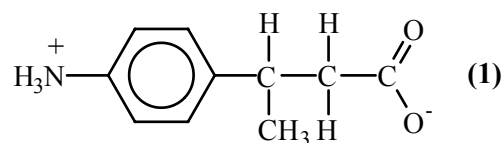
1

(ii) RCH(NH<sub>2</sub>)COOH (1)

Does not fit the formula because NH<sub>2</sub> and COOH are not attached to the same carbon (1) AW

2

(b) (i)

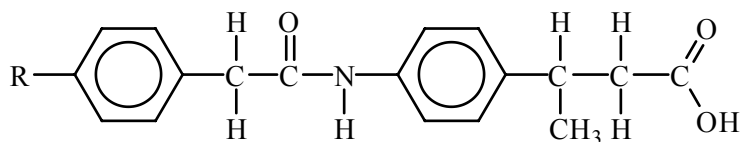


1

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

1

(c)

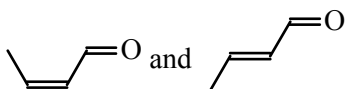


displayed peptide bond **(1)**  
rest of the structure also correct **(1)**  
(allow full marks for a correct anhydride structure)

2

[7]

8.



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

2

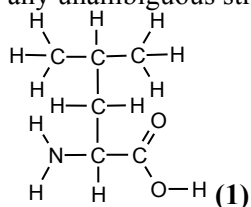
[2]

9. (a) (i)  $\text{RCH}(\text{NH}_2)\text{COOH}$  **(1)**

1

allow groups *R*, *CH*, *NH<sub>2</sub>*, *COOH* in any order<sub>2</sub>

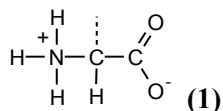
(ii) any unambiguous structure, e.g.:



1

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

(ii) description or diagram to show proton/H<sup>+</sup> transfer from COOH to NH<sub>2</sub> (1)



*NOT just 'hydrogen' transfer*

2

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

named strong acid/base

an enzyme (which need not be named) (1)

*NOT conc HNO<sub>3</sub> or conc H<sub>2</sub>SO<sub>4</sub>*

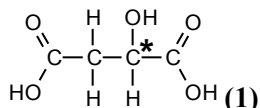
2

(ii) hydrolysis (1)

1

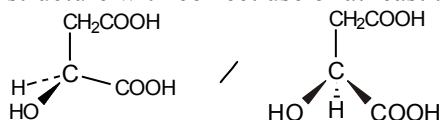
[8]

10. (i)



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 arrangement (1)

1

(ii) cis-trans / geometric (1)

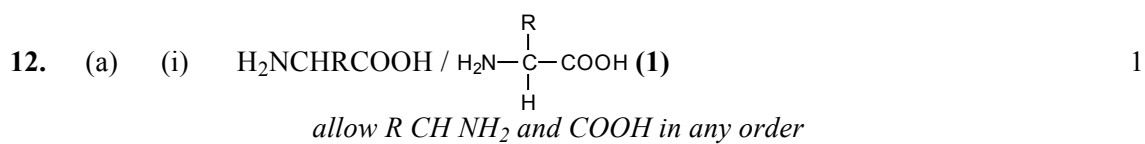
1

(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]



- (ii) they both have the  $\text{H}_2\text{N}-\overset{\vdots}{\underset{\text{H}}{\text{C}}}-\text{COOH}$  group / or in words (1)  
*NOT just "they both have NH<sub>2</sub> and COOH"*

R group is H in glycine and CH<sub>2</sub>CH<sub>2</sub>COOH in glutamic acid (1) 2

(b)

$\begin{array}{c} \text{H} \\   \\ \text{H}_3\text{N}^+-\text{C}-\text{COOH} \\   \\ \text{CH}_2 \\   \\ \text{CH}_2 \\   \\ \text{COOH} \end{array}$	<p>-NH<sub>3</sub><sup>+</sup> (1)</p> <p>-COOH and side chain unaffected (1)</p>	$\begin{array}{c} \text{H} \\   \\ \text{H}_2\text{N}-\text{C}-\text{COO}^- \\   \\ \text{CH}_2 \\   \\ \text{CH}_2 \\   \\ \text{COO}^- \end{array}$	<p>one -COO<sup>-</sup> (1)</p> <p>both -COO<sup>-</sup> (1)</p> <p>H<sub>2</sub>N- and rest of molecule (1)</p>
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5

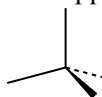
(c) **glutamic acid/molecule with optical isomers ...**

... 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

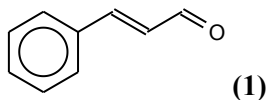
**quality of written communication**

for correct use and organisation of at least **one** technical term:

\*(in the correct place), non-superimposable, enantiomer, stereoisomer(ism),  
tetrahedral, assymmetric (1)

[16]

13. (a)



1

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

two different groups on each carbon (of the C=C) **AW** (1)

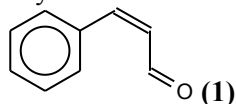
2

*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

[5]

14. (i) water / evidence of a solution in water – eg  
(aq), 'dil', '6M' or 'conc' for HCl (1)

*NOT conc HNO<sub>3</sub>*

*or conc H<sub>2</sub>SO<sub>4</sub>*

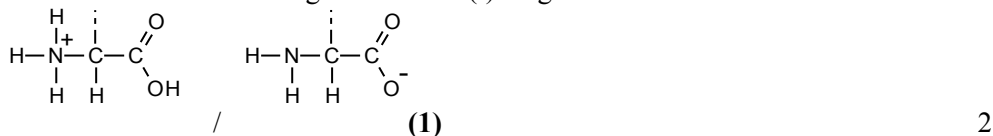
a named strong acid or alkali (heated under) reflux /

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

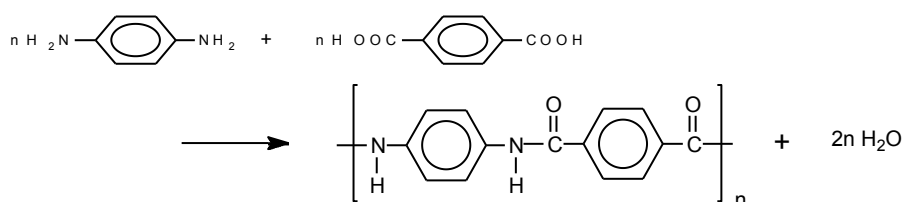


(iv) reaction with water to split/break down the compound (1)  
peptide bond in the compound is broken / diagram to show AW (1) 2

[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) condensation (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]