

# Interactive Example Candidate Responses

## Paper 42 (May/June 2016), Question 7

### Cambridge International AS & A Level Chemistry 9701

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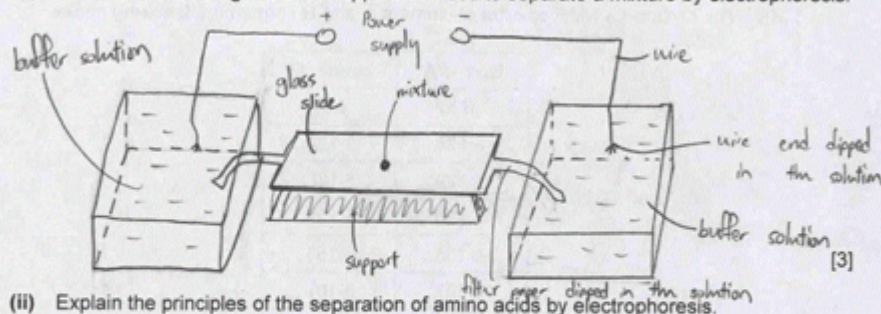
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## 7 (a) Amino acids can be separated by electrophoresis.

(i) Draw a labelled diagram of the apparatus used to separate a mixture by electrophoresis.



(ii) Explain the principles of the separation of amino acids by electrophoresis.

It is based on acid-base reaction.  
Amino acid will move to either end depending on its isoelectric point and charges on amino acid.

[2]

(b) Electrophoresis is usually carried out in a buffer solution.

Given three buffers, with pH values of 2.0, 7.0 and 12.0, suggest, with a reason, which buffer would be the most suitable for the separation of the following amino acid mixtures. Your reasons should refer to the structure of each molecule. (The structures of these amino acids are given in the Data Booklet.)

(i) Asp and Val

buffer pH 7.0

reason Since valine is zwitterion, it will not move.  
For aspartic acid, it carries a negative charge and will move to positive pole.  
due to its  $\text{COO}^-$  group.

(ii) Lys and Ser

buffer pH 7.0

reason Serine is a zwitterion and will not move in a neutral solution.  
Lysine carries a positive charge due to  $\text{NH}_3^+$  and will move to the negative pole.

(iii) Tyr and Phe

buffer pH 7.0

reason Phenylalanine will gain a negative charge ( $\text{COO}^-$  +  $\text{OH}^-$ ) →  
Phenylalanine is a zwitterion and will not move.  
Tyrosine is slightly acidic due to the phenolic group, hence there is a negative charge ( $\text{O}^-$ ) and it will move to positive pole.

[3]

Your  
Mark

7(a)(i)

7(a)(ii)

7(b)(i)

7(b)(ii)

7(b)(iii)

7(c)(i)

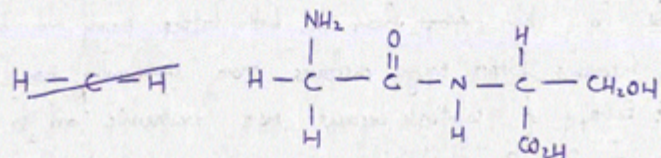
7(c)(ii)

## Q7 Mark scheme

(a)(i)	<p>labelled with M1: DC power supply + and - / battery / cell / + and - sign (on cell / electrodes) with a complete circuit M2: buffer solution / electrolyte labelled M3: (amino acid) mixture / x on (filter) paper / gel / agarose</p>
	<p>d.c. power supply glass slides electrolyte amino acid mixture placed here filter paper soaked in buffer solution</p>
(a)(ii)	<p>direction of movement related to charge (of amino acids) distance travelled depends on charge / Mr (of amino acids)</p>
(b)(i)	<p>Asp + Val: pH 12 because Asp will be <math>\text{CH}_2\text{COO}^-</math> (R-group) moves further (to positive electrode than Val) or pH 12 Asp more negative so moves further (to positive electrode) or pH 12 because Asp has a charge of 2- but Val has a charge of 1- or best at pH 7 because Asp will be negatively charged (anionic) but Val neutral</p>
(b)(ii)	<p>Lys + Ser: pH 2 because Lys will be <math>(\text{CH}_2)_4\text{NH}_3^+</math> (R-group) moves further (to negative electrode than Ser) or pH 2 Lys more positive so moves further (to negative electrode) or pH 2 because Lys has a charge of 2+ and Ser has a charge of 1+ or pH 7 because Lys is positively charged (cationic) but Ser neutral / zwitterionic</p>
(b)(iii)	<p>Tyr + Phe: pH 12 because Tyr will be <math>\text{C}_6\text{H}_5\text{CH}_2\text{O}^-</math> (R-group) moves further / more / faster (to positive electrode than Phe) or pH 12 because Tyr has a charge of 2- but Phe has a charge of 1-</p>

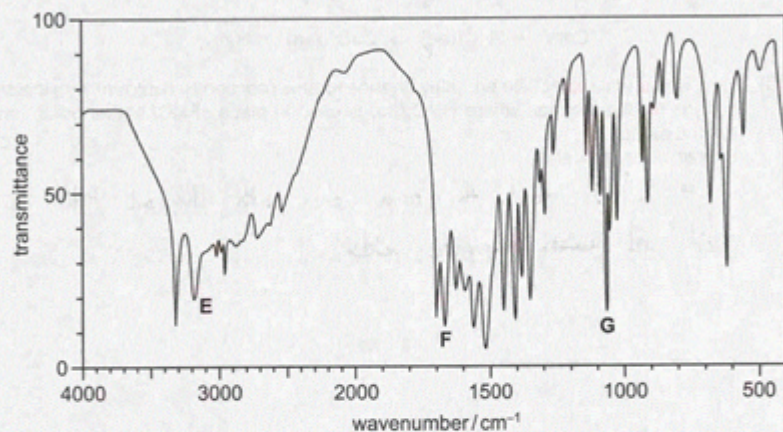


(c) (i) Draw the structure of the dipeptide Gly-Ser, showing the peptide bond in full.



[2]

The infra-red spectrum of Gly-Ser is shown below.



(ii) Use the *Data Booklet* to identify the bond in the molecule of Gly-Ser that is responsible for each of the peaks indicated on the above infra-red spectrum.

E ..... ~~O-H~~ O-H

F ..... C=O

G ..... C-O

[2]

[Total: 12]

Your  
Mark

7(a)(i)

7(a)(ii)

7(b)(i)

7(b)(ii)

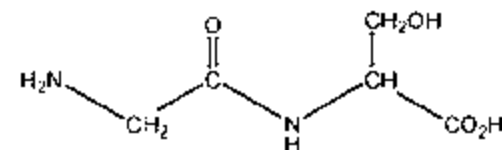
7(b)(iii)

7(c)(i)

7(c)(i)

### Q7 Mark scheme

(c)(i)



M1: for -CONH- as shown above

M2: for rest of molecule and correct connectivity of the bonds

[3]

(c)(ii)

from the IR spectrum

• E is O-H or N-H (allow NH<sub>2</sub>)

• F is C=O

• G is C-O

[2]

[Total: 9]



7 (a) Amino acids can be separated by electrophoresis.

(i) Draw a labelled diagram of the apparatus used to separate a mixture by electrophoresis.



(ii) Explain the principles of the separation of amino acids by electrophoresis.

A DC ~~can~~ voltage is provided which causes the amino acids to move according to their charge that is +ve towards cathode -ve towards anode. The bigger the molecule slower it will move, less distance covered. [2]

(b) Electrophoresis is usually carried out in a buffer solution.

Given three buffers, with pH values of 2.0, 7.0 and 12.0, suggest, with a reason, which buffer would be the most suitable for the separation of the following amino acid mixtures. Your reasons should refer to the structure of each molecule. (The structures of these amino acids are given in the Data Booklet.)

(i) Asp and Val

buffer pH 12.0

reason They both are acidic in nature and will therefore move better in alkaline conditions

(ii) Lys and Ser

buffer pH

reason

(iii) Tyr and Phe

buffer pH 7.0

reason The difference in negativity is so great that the mixture will be separated. [3]

Your  
Mark

7(a)(i)

7(a)(ii)

7(b)(i)

7(b)(ii)

7(b)(iii)

7(c)(i)

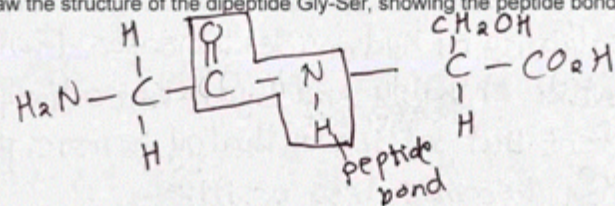
7(c)(i)

## Q7 Mark scheme

(a)(i)	labelled with M1: DC power supply + and – / battery / cell / + and – sign (on cell / electrodes) with a complete circuit M2: buffer solution / electrolyte labelled M3: (amino acid) mixture / <b>x</b> on (filter) paper / gel / agarose [3]
(a)(ii)	direction of movement related to charge (of amino acids) distance travelled depends on charge / Mr (of amino acids) [2]
(b)(i)	Asp + Val: <b>pH 12</b> because Asp will be $\text{CH}_2\text{COO}^-$ (R-group) moves further (to positive electrode than Val) <b>or pH 12</b> Asp more negative so moves further (to positive electrode) <b>or pH 12</b> because Asp has a charge of 2– but Val has a charge of 1– <b>or best at pH 7</b> because Asp will be negatively charged (anionic) but Val neutral [1]
(b)(ii)	Lys + Ser: <b>pH 2</b> because Lys will be $(\text{CH}_2)_4\text{NH}_3^+$ (R-group) moves further (to negative electrode than Ser) <b>or pH 2</b> Lys more positive so moves further (to negative electrode) <b>or pH 2</b> because Lys has a charge of 2+ and Ser has a charge of 1+ <b>or pH 7</b> because Lys is positively charged (cationic) but Ser neutral / zwitterionic [1]
(b)(iii)	Tyr + Phe: <b>pH 12</b> because Tyr will be $\text{C}_6\text{H}_5\text{CH}_2\text{O}^-$ (R-group) moves further / more / faster (to positive electrode than Phe) <b>or pH 12</b> because Tyr has a charge of 2– but Phe has a charge of 1– [1]

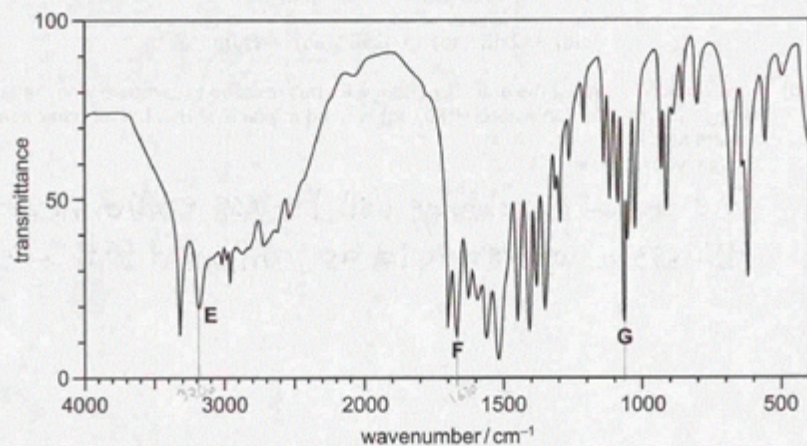


(c) (i) Draw the structure of the dipeptide Gly-Ser, showing the peptide bond in full.



[2]

The infra-red spectrum of Gly-Ser is shown below.



(ii) Use the *Data Booklet* to identify the bond in the molecule of Gly-Ser that is responsible for each of the peaks indicated on the above infra-red spectrum.

E R-OH  
F C=O  
G C-O

[2]

[Total: 12]

Your  
Mark

7(a)(i)

7(a)(ii)

7(b)(i)

7(b)(ii)

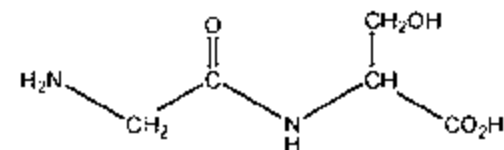
7(b)(iii)

7(c)(i)

7(c)(i)

## Q7 Mark scheme

(c)(i)



M1: for -CONH- as shown above

M2: for rest of molecule and correct connectivity of the bonds

[3]

(c)(ii)

from the IR spectrum

- E is O-H or N-H (allow NH<sub>2</sub>)
- F is C=O
- G is C-O

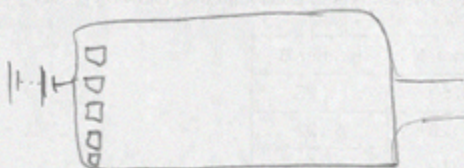
[2]

[Total: 9]



7 (a) Amino acids can be separated by electrophoresis.

(i) Draw a labelled diagram of the apparatus used to separate a mixture by electrophoresis.



[3]

(ii) Explain the principles of the separation of amino acids by electrophoresis.

By the principles of separation of amino acids by electrophoresis amino acid separates by forming ions. First  $\text{CO}_2\text{H}$  separates followed by  $\text{NH}_2$

[2]

(b) Electrophoresis is usually carried out in a buffer solution.

Given three buffers, with pH values of 2.0, 7.0 and 12.0, suggest, with a reason, which buffer would be the most suitable for the separation of the following amino acid mixtures. Your reasons should refer to the structure of each molecule.

(The structures of these amino acids are given in the Data Booklet.)

(i) Asp and Val

buffer pH 12.0

reason pH value 2.0 as the structure of carboxylic group

and alkane group which becomes acidic can be separated by acidic buffer.

(ii) Lys and Ser

buffer pH 12.0

reason Presence of amine makes the solution basic and basic and acidic buffer would release the base due to common ion effect.

(iii) Tyr and Phe

buffer pH 7.0

reason The appcar to be neutral which can help to bring about a charge in both the compounds.

[3]

Your  
Mark

7(a)(i)

7(a)(ii)

7(b)(i)

7(b)(ii)

7(b)(iii)

7(c)(i)

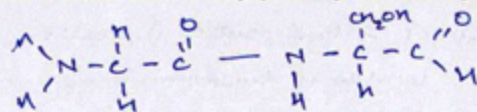
7(c)(ii)

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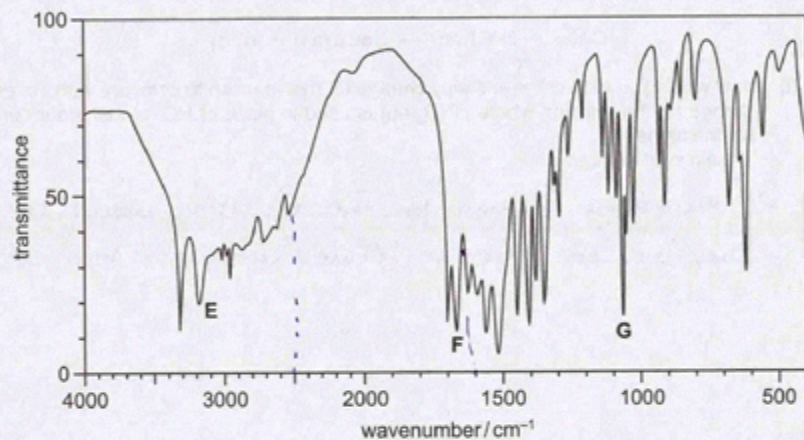


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The infra-red spectrum of Gly-Ser is shown below.



(ii) Use the *Data Booklet* to identify the bond in the molecule of Gly-Ser that is responsible for each of the peaks indicated on the above infra-red spectrum.

E ..... O-H ..... carboxylic  
F ..... C=O ..... amides  
G ..... C-O ..... carbonyl

[2]

[Total: 12]

Your  
Mark

7(a)(i)

7(a)(ii)

7(b)(i)

7(b)(ii)

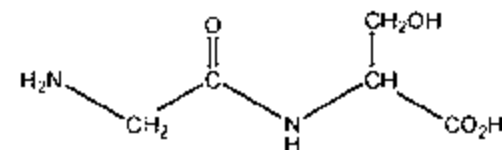
7(b)(iii)

7(c)(i)

7(c)(i)

## Q7 Mark scheme

(c)(i)



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M2: for rest of molecule and correct connectivity of the bonds

[3]

(c)(ii)

from the IR spectrum

- E is O-H or N-H (allow NH2)
- F is C=O
- G is C-O

[2]

[Total: 9]



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