

Nitrogen Compounds

Question Paper 2

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Nitrogen Compounds
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 2

Time Allowed: 74 minutes

Score: /61

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

1 Electrophoresis is a technique which can be used to separate amino acids or peptide fragments present in a mixture.

(a) Draw a diagram to show the apparatus used to carry out electrophoresis. You should label each of the relevant parts of the apparatus.

[4]

(b) How far an amino acid will travel during electrophoresis depends on the pH of the solution. For a given potential difference, state **two other** factors that will affect how far a given amino acid travels in a fixed time during electrophoresis.

1.
.....
2.
.....

[2]

(c) A number of analytical and separation techniques rely on substances having different partition coefficients.

State what is meant by the term *partition coefficient*.

-
.....
.....

[1]

- (d) The partition coefficient of **X** between ethoxyethane and water is 40.0.
A solution contains 4.00 g of **X** dissolved in 0.500 dm³ of water.

Calculate the mass of **X** that can be extracted from this aqueous solution by shaking it with

- (i) 0.050 dm³ of ethoxyethane,

- (ii) two successive portions of 0.025 dm³ of ethoxyethane.

- 2 Naturally-occurring α -amino acids, $\text{RCH}(\text{NH}_2)\text{CO}_2\text{H}$, can be classified as *amphiprotic* substances. An amphiprotic substance is one which can act as both a Brønsted-Lowry acid and base.

α -amino acid	R group
alanine	CH_3-
aspartic acid	HO_2CCH_2-
glycine	$\text{H}-$
lysine	$\text{H}_2\text{N}(\text{CH}_2)_4-$
threonine	$\text{CH}_3\text{CH}(\text{OH})-$
serine	HOCH_2-

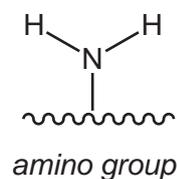
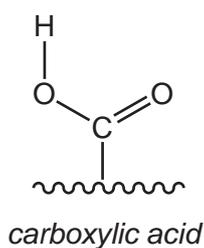
- (a) What is the Brønsted-Lowry definition of an acid?

.....

.....

[1]

- (b) All α -amino acids are soluble in water since they can form hydrogen bonds with water molecules and can also exist as zwitterions. Draw diagrams to show how the carboxylic acid and amino groups of alanine can form hydrogen bonds with water molecules.



- (ii) Draw the structure of the zwitterionic form of glycine.

[5]

- (c) The amino acid alanine can be formed by the reaction of $\text{CH}_3\text{CHClCO}_2\text{H}$ with an excess of ammonia.
Outline a mechanism for this reaction using curly arrows.

[3]

- (d) Amino acids can form different ions at different pH values.
Suggest the structures of the ions formed from the α -amino acids below at the respective pH value.

lysine at pH 1	aspartic acid at pH 14

[2]

- (e) How many different **dipeptides** is it possible to synthesise, each containing two of the three amino acids alanine, serine and lysine?
.....
- (ii) Write the structural formula of one of these dipeptides incorporating serine and alanine.

[3]

(f) Most naturally-occurring amino acids have a chiral centre and exhibit stereoisomerism.

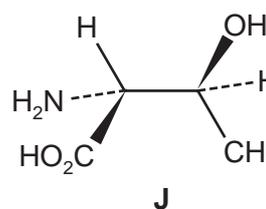
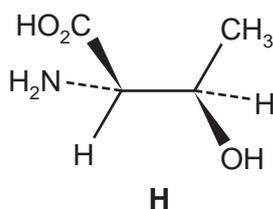
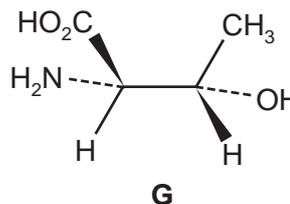
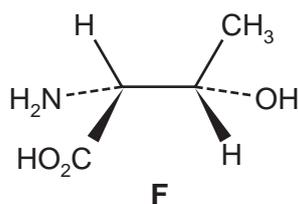
(i) Define the term *stereoisomerism*.

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There are **four** optical isomers of threonine.

Some of these optical isomers are drawn below.

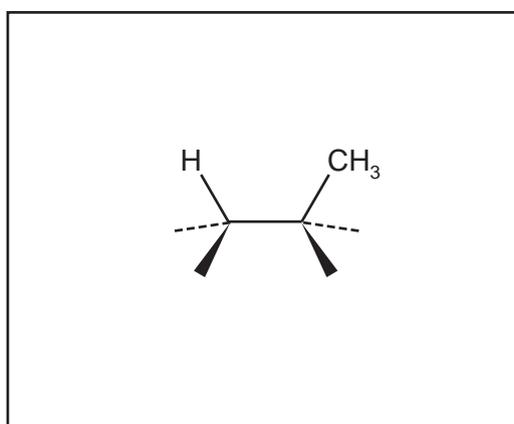


When answering this question, remember that completely free rotation about a C–C single bond occurs in these compounds.

(ii) Which of the structures **G**, **H** or **J** is identical to structure **F**?

(iii) The other two of the structures **G**, **H** or **J** represent **two** of the **three** other possible optical isomers of threonine.

Complete the following partial structure of the **fourth** optical isomer.

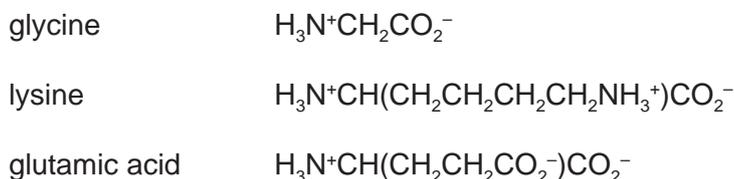


[3]

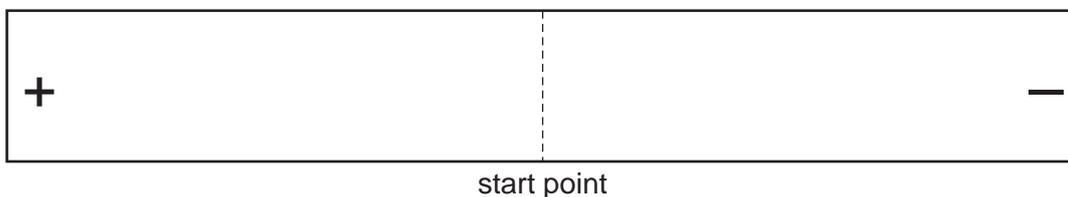
[Total: 17]

3 The analysis of a protein may be carried out by breaking it down into its amino acids. These can then be separated by a process called electrophoresis.

(a) The structures of glycine, lysine and glutamic acid at pH 7 are shown.



Draw and label three circles on the chart below to indicate the likely position of each of these amino acids after electrophoresis of a solution containing these amino acids in a buffer at pH 7.



[3]

(b) Some organic compounds have very different solubilities in water and in organic solvents such as hexane. They may be extracted from an aqueous reaction mixture by shaking the mixture with portions of hexane and separating the two layers. The process of distribution of a compound between two solvents is called *partition*.

(i) State what is meant by the term *partition coefficient*.

.....

.....

.....

(ii) One of the concerns about organic pollutants, such as pesticide residues, is that they can enter the food chain and become concentrated in human breast milk. Explain how this can happen.

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[3]

- (c) Propene was treated with bromine in the presence of chloride ions and the product analysed using mass spectrometry.

A group of peaks was found in the range m/e 156–160 with the following relative heights.

m/e	relative height
156	3
158	4
160	1

- (i) Identify the species responsible for each of these peaks.

156

158

160

A large peak was present in the spectrum with a m/e value of less than 20.

- (ii) Suggest the m/e value for the peak and the species that produced it.

m/e

species

[4]

[Total: 10]

4 (a) The table shows the structures of four amino acids found in proteins in the human body.

Complete the table by indicating the type of tertiary interaction each side-chain is most likely to have when its amino acid is present in a protein chain.

amino acid	structure	type of interaction
alanine	$\text{H}_2\text{NCH}(\text{CH}_3)\text{CO}_2\text{H}$	
cysteine	$\text{H}_2\text{NCH}(\text{CH}_2\text{SH})\text{CO}_2\text{H}$	
lysine	$\text{H}_2\text{NCH}((\text{CH}_2)_4\text{NH}_2)\text{CO}_2\text{H}$	
serine	$\text{H}_2\text{NCH}(\text{CH}_2\text{OH})\text{CO}_2\text{H}$	

[3]

(b) Metal ions play an important role in the biochemistry of the human body. For each of the following metal ions, outline one of the places in the body it can be found and its main role there.

iron

.....

.....

potassium

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zinc

.....

.....

[3]

(c) Many chemical reactions at a cellular level require energy in order to take place. This energy is largely provided by the breakdown of one particular compound.

(i) Write an equation showing the breakdown of this compound.

.....

(ii) What type of chemical reaction is this?

.....

[2]

(d) Cystic fibrosis is a genetic disease caused by a mutation in the DNA sequence resulting in the production of a faulty version of an important protein which acts as an ion pump in the cell membrane. This pump controls the flow of ions into and out of cells. People with the faulty protein show two major symptoms.

- water is retained in cells in the lungs resulting in the formation of a thick, sticky mucous outside the cells;
- their sweat is very salty.

Based on the information given for people with cystic fibrosis,

(i) suggest which ions are involved in the ion flow,

.....

.....

(ii) suggest and explain what type of bonding might result in thick or sticky mucous.

.....

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[2]

[Total: 10]

5 Ammonia is an important industrial chemical which is manufactured on a large scale by using the Haber process.

(a) Write a balanced equation, with state symbols, for the reaction occurring in the Haber process.

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(ii) Give **three** essential operating conditions that are used in the Haber process.

.....

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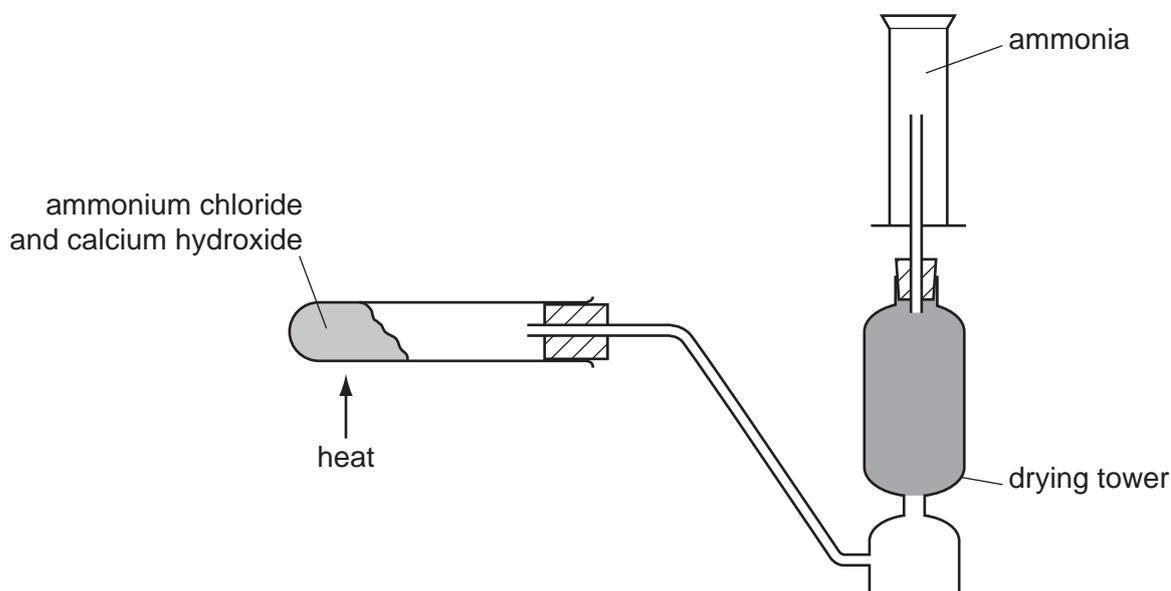
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(iii) State **one** large scale use of ammonia.

.....

[5]

(b) Ammonia may be prepared in a school or college laboratory by using the apparatus below.



The reaction involves the displacement of ammonia from one of its compounds.

(i) Give the formulae of the two reactants that are heated together to produce ammonia.

..... and

(ii) Construct a balanced equation for the reaction between your two reagents.

.....

(iii) Common drying agents include calcium oxide, concentrated sulfuric acid and phosphorus(V) oxide.

Which **one** of these would be used in the drying tower in this experiment? Explain your answer.

.....
.....

[5]

(c) Ammonia is a weak base which forms salts containing the ammonium ion.

Describe, with the aid of an equation, the formation and structure of the ammonium ion. You should use displayed formulae in your answer.

[3]

[Total: 13]