

# Nitrogen Compounds

## Question Paper 4

<b>Level</b>	International A Level
<b>Subject</b>	Chemistry
<b>Exam Board</b>	CIE
<b>Topic</b>	Nitrogen Compounds
<b>Sub-Topic</b>	
<b>Paper Type</b>	Theory
<b>Booklet</b>	Question Paper 4

**Time Allowed:** 77 minutes

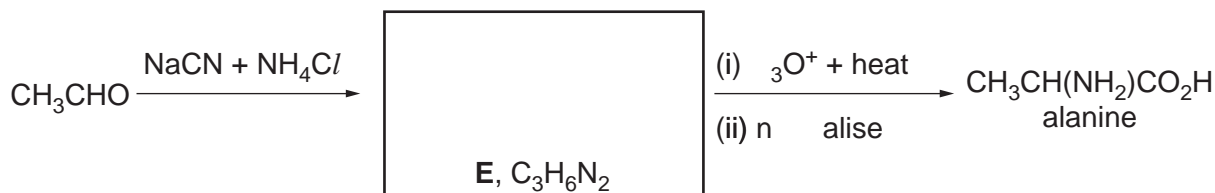
**Score:** /64

**Percentage:** /100

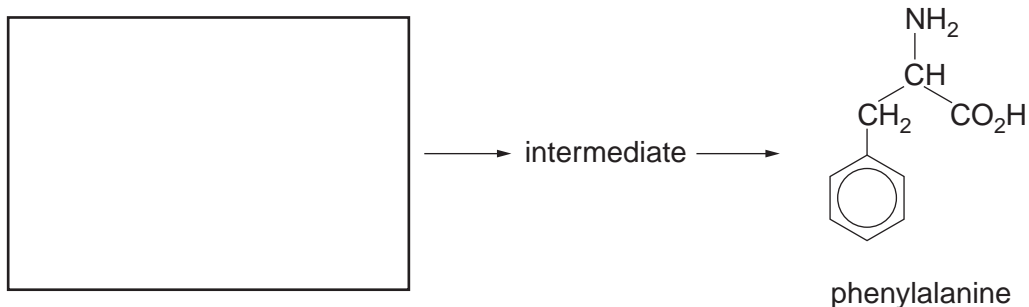
**Grade Boundaries:**

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

- 1 (a) Amino acids such as alanine are essential building blocks for making proteins. They can be synthesised by a general reaction of which the following is an example.



- (i) Suggest the structure of the intermediate compound **E** by drawing its structural formula in the box above.
- (ii) Suggest, in the box below, the structural formula of the starting material needed to synthesise phenylalanine by the above general reaction.



[2]

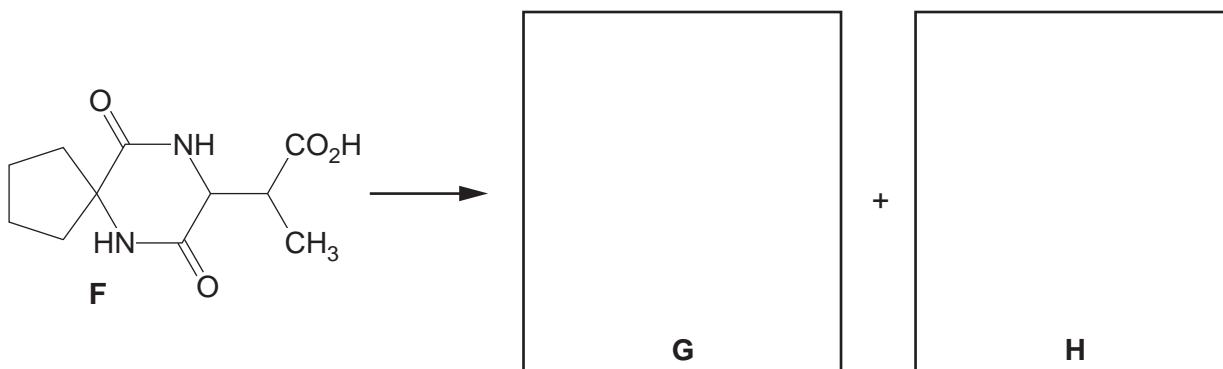
- (b) (i) What is a *protein*?

.....

- (ii) Using alanine as an example, draw a diagram to show how proteins are formed from amino acids. Show two repeat units in your answer.

[3]

(c) The hydrolysis of compound **F** produces two compounds **G** and **H**.



(i) State the reagents and conditions needed for this hydrolysis.

.....

(ii) Draw the structures of the two products **G** and **H** in the boxes above.

[3]

(d) (i) Draw the zwitterionic structure of alanine.

(ii) Suggest the structural formulae of the zwitterions that could be formed from the following compounds.

compound	zwitterion

[4]

(e) Solutions of amino acids are good buffers.

(i) What is meant by the term *buffer*?

.....

(ii) Write an equation to show how a solution of alanine,  $\text{CH}_3\text{CH}(\text{NH}_2)\text{CO}_2\text{H}$ , behaves as a buffer in the presence of an acid such as  $\text{HCl}(\text{aq})$ .

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(iii) Briefly describe how the pH of blood is controlled.

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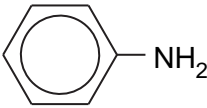
(iv) Calculate the pH of the buffer formed when  $10.0\text{ cm}^3$  of  $0.100\text{ mol dm}^{-3}$   $\text{NaOH}$  is added to  $10.0\text{ cm}^3$  of  $0.250\text{ mol dm}^{-3}$   $\text{CH}_3\text{CO}_2\text{H}$ , whose  $\text{p}K_{\text{a}} = 4.76$ .

pH = .....

[7]

[Total: 19]

- 2 Ethanolamine and phenylamine are two organic bases that are industrially important. Ethanolamine is a useful solvent with basic properties, whilst phenylamine is an important starting material in the manufacture of dyes and pharmaceuticals. The following table lists some of their properties, together with those of propylamine.

compound	formula	$M_r$	boiling point/°C	solubility in water
propylamine	$\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$	59	48	fairly soluble
ethanolamine	$\text{HOCH}_2\text{CH}_2\text{NH}_2$	61	170	very soluble
phenylamine		93	184	sparingly soluble

- (a) Suggest why the boiling point of ethanolamine is much higher than that of propylamine. Draw a diagram to illustrate your answer.

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 .....

[2]

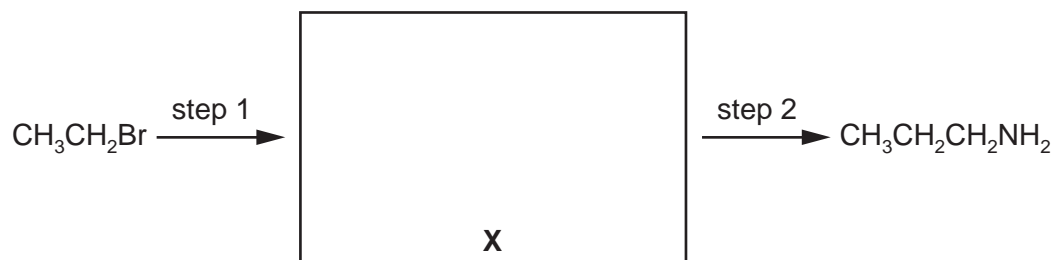
- (b) Describe and explain the relative basicities of propylamine and phenylamine.

.....  
 .....  
 ..... [2]

- (c) Write an equation showing ethanolamine acting as a Brønsted-Lowry base.

..... [1]

(d) Propylamine can be synthesised from bromoethane by the following route.



(i) Draw the structure of the intermediate compound **X** in the box above.

(ii) Suggest reagents and conditions for

step 1 .....

step 2 .....

[3]

(e) Apart from their relative basicities, ethanolamine and phenylamine differ in many of their reactions.

For **each** of these two compounds, describe **one** test that would give a positive result with the stated compound, but a negative result with the other.

**ethanolamine**

test .....

observation .....

**phenylamine**

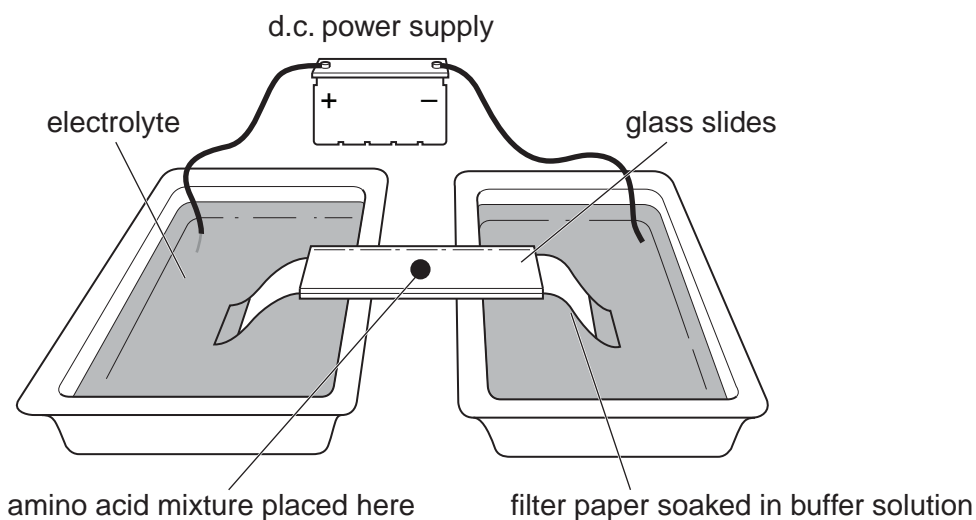
test .....

observation .....

[4]

[Total: 12]

- 3 A mixture of amino acids may be separated using electrophoresis. A typical practical set-up is shown in the diagram.



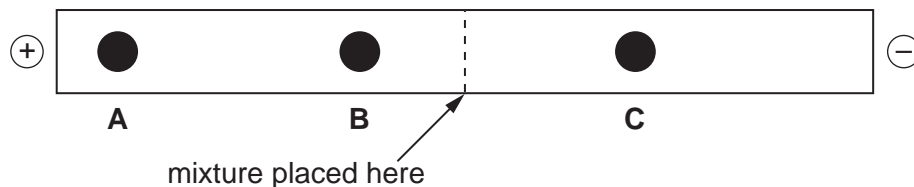
- (a) When the power supply is switched on, some amino acids may **not** move, but remain stationary. Suggest an explanation for this observation.

.....  
 .....  
 ..... [2]

- (b) The amino acid glycine has the formula  $\text{H}_2\text{NCH}_2\text{CO}_2\text{H}$ . Identify the species formed on the filter paper if glycine moves to the left (positive) end of the filter paper.

..... [1]

- (c) The following result was obtained from another electrophoresis. What can be deduced about the relative sizes of, and charges on, the amino acid species **A**, **B** and **C**?



amino acid	relative size	charge
<b>A</b>		
<b>B</b>		
<b>C</b>		

(d) The sequence of amino acids in a polypeptide may be determined by partial hydrolysis of the chain into smaller pieces, often tripeptides.

(i) Following such a partial hydrolysis, the following tripeptides were obtained from a given polypeptide.

ala-gly-asp    gly-ala-gly    lys-val-ser    ser-ala-gly    val-ser-ala

Given that the N-terminal amino acid is lysine (lys) suggest the amino acid sequence of the **shortest** polypeptide that would give the above tripeptides.

.....

The structural formulae of the amino acids in the polypeptide are given below.

abbreviation	amino acid	structural formula
ala	alanine	$\text{H}_2\text{NCH}(\text{CH}_3)\text{CO}_2\text{H}$
asp	aspartic acid	$\text{H}_2\text{NCH}(\text{CH}_2\text{CO}_2\text{H})\text{CO}_2\text{H}$
gly	glycine	$\text{H}_2\text{NCH}_2\text{CO}_2\text{H}$
lys	lysine	$\text{H}_2\text{NCH}(\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2)\text{CO}_2\text{H}$
ser	serine	$\text{H}_2\text{NCH}(\text{CH}_2\text{OH})\text{CO}_2\text{H}$
val	valine	$\text{H}_2\text{NCH}(\text{CH}(\text{CH}_3)_2)\text{CO}_2\text{H}$

(ii) Which of the tripeptides in (i) has the lowest  $M_r$ ?

.....

(iii) Select **one** amino acid **from those listed in the table** which contains an ionic side-chain at pH 8.

.....

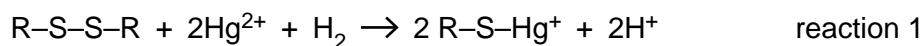
[4]

[Total: 10]



4 Whilst small amounts of some metal ions are vital in the human body, others can be highly toxic.

(a)  $\text{Hg}^{2+}$  ions are toxic for a number of reasons.  $\text{Hg}^{2+}$  ions can react with the R–S–S–R group, which is found in proteins.



(i) What is the name of the R–S–S–R group in proteins?

.....

(ii) Which level of protein structure will be affected by reaction 1?

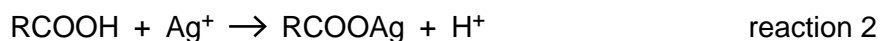
.....  
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(iii) Why will this affect the activity of an enzyme?

.....  
.....

[3]

(b)  $\text{Ag}^+$  ions can combine with free –COOH groups in the side chains of the amino acid residues in proteins to form partially covalent silver carboxylates.



(i) What type of behaviour is the –COOH group showing in reaction 2?

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.....

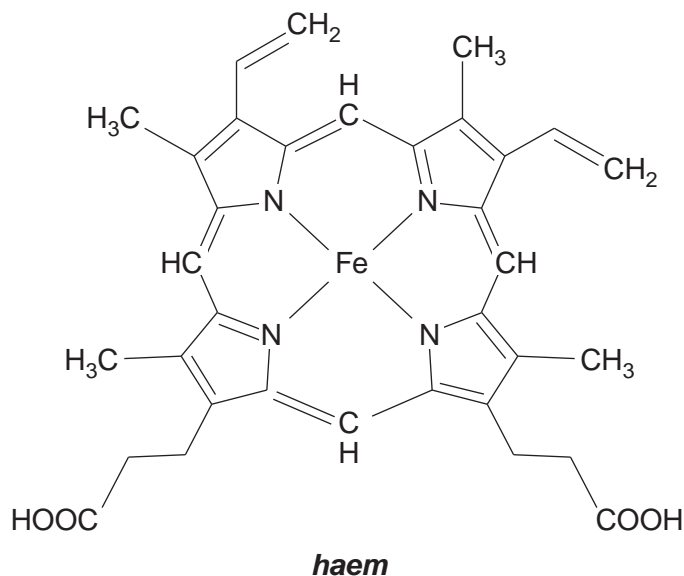
(ii) What types of R group interactions will be affected by reaction 2? Explain your answer.

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.....  
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.....

[4]

- (c) By contrast, iron is an extremely important metal used in haemoglobin to transport oxygen molecules from the lungs to muscle cells and to carry carbon dioxide in the reverse direction.

One haemoglobin molecule contains four haem groups, each of which contains one iron atom. In the haem group four nitrogen atoms are in the same plane as the iron atom. The oxygen molecule is attached above this plane, and the iron atom is joined to a protein chain below this plane.



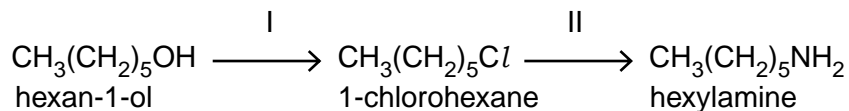
- (i) How many oxygen **atoms** could one haemoglobin molecule transport?  
 .....
- (ii) By what type of bonding is the oxygen molecule likely to be held to the iron atom in haem?  
 .....
- (iii) What is the geometry of bonding around the iron atom?  
 .....

[3]

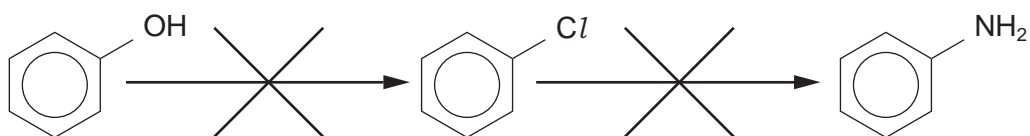
[Total: 10]

- 5 Phenol and chlorobenzene are less reactive towards certain reagents than similar non-aromatic compounds.

Thus hexan-1-ol can be converted into hexylamine by the following two reactions,



whereas neither of the following two reactions takes place.



- (a) (i) Suggest reagents and conditions for

reaction I, .....

reaction II. ....

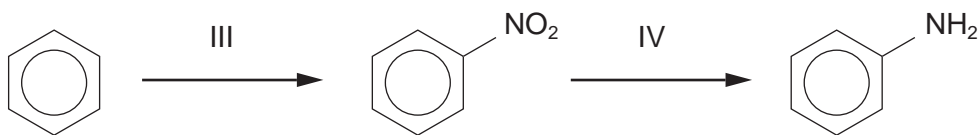
- (ii) What *type of reaction* is reaction II? .....

- (iii) Suggest a reason why chlorobenzene is much less reactive than 1-chlorohexane.

.....  
 .....

[4]

(b) Phenylamine can be made from benzene by the following two reactions.



(i) Suggest reagents and conditions for

reaction III, .....

reaction IV. ....

(ii) State the *type of reaction* for

reaction III, .....

reaction IV. ....

[5]

(c) Suggest a reagent that could be used to distinguish phenylamine from hexylamine.

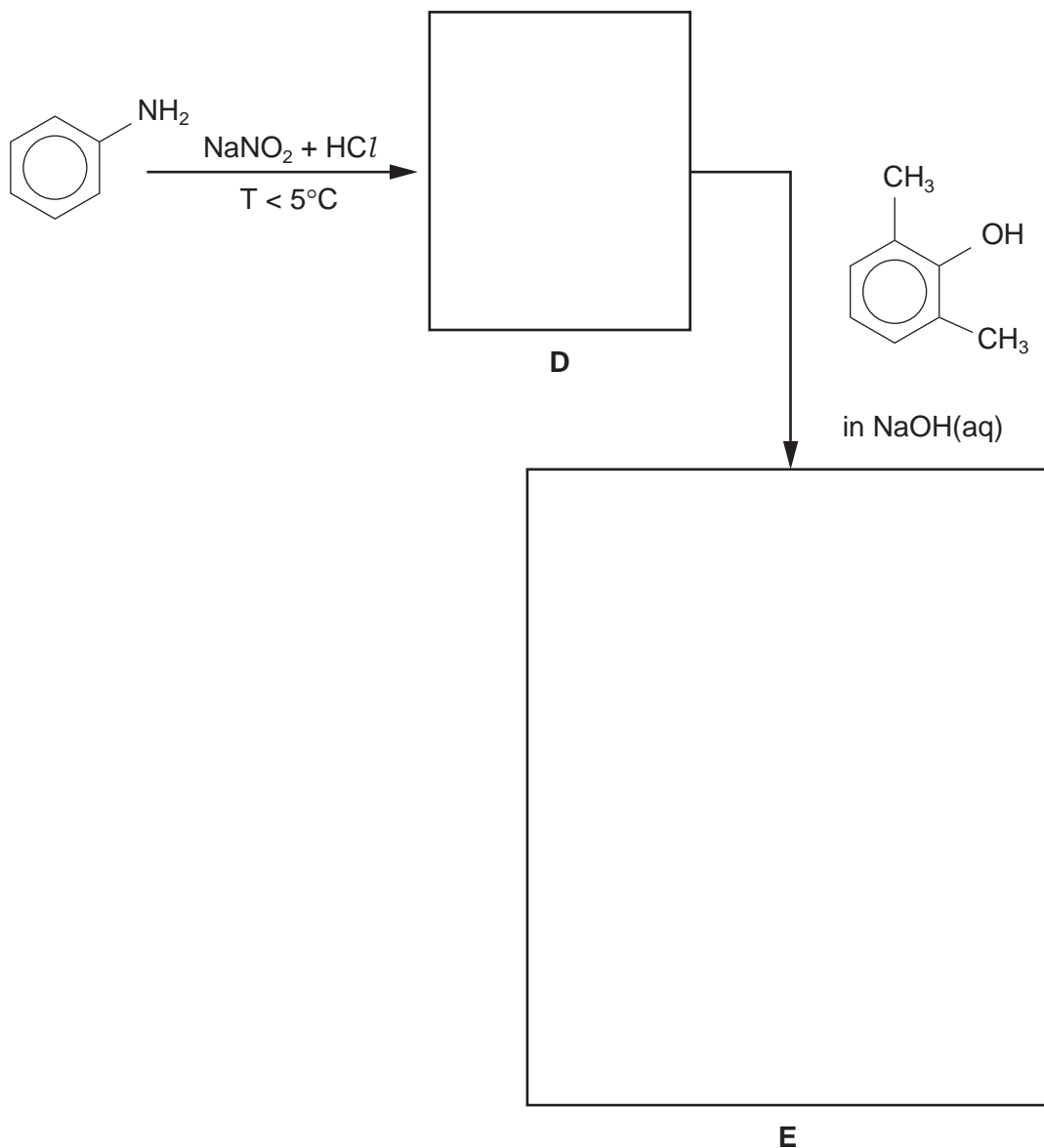
reagent and conditions .....

observation with phenylamine .....

observation with hexylamine.....

[2]

- (d) Phenylamine is used to make azo dyes. In the following boxes draw the structural formula of the intermediate **D** and of the azo dye **E**.



[2]

[Total: 13]