

# Nitrogen Compounds

## Question Paper 1

<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 1

**Time Allowed:** 68 minutes

**Score:** /56

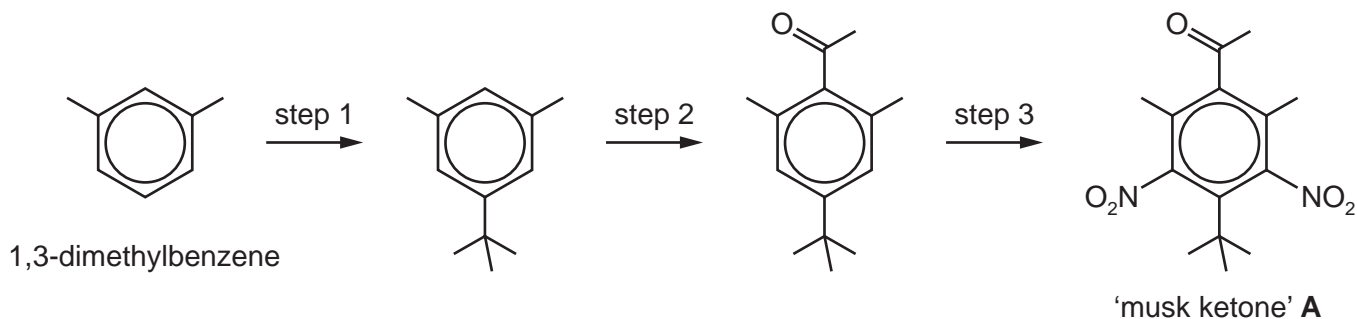
**Percentage:** /100

**Grade Boundaries:**

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

1 1,3-dimethylbenzene is a useful starting material for several commercially important compounds.

(a) The artificial ‘musk ketone’, **A**, is a perfume agent added to many cosmetics and detergents. It is made from 1,3-dimethylbenzene by the following route.



(i) The only by-product of step 2 is HCl.

Suggest the reagent that was used in this step.

..... [1]

(ii) Suggest the *type of reaction* that is occurring during both step 2 and step 3.

..... [1]

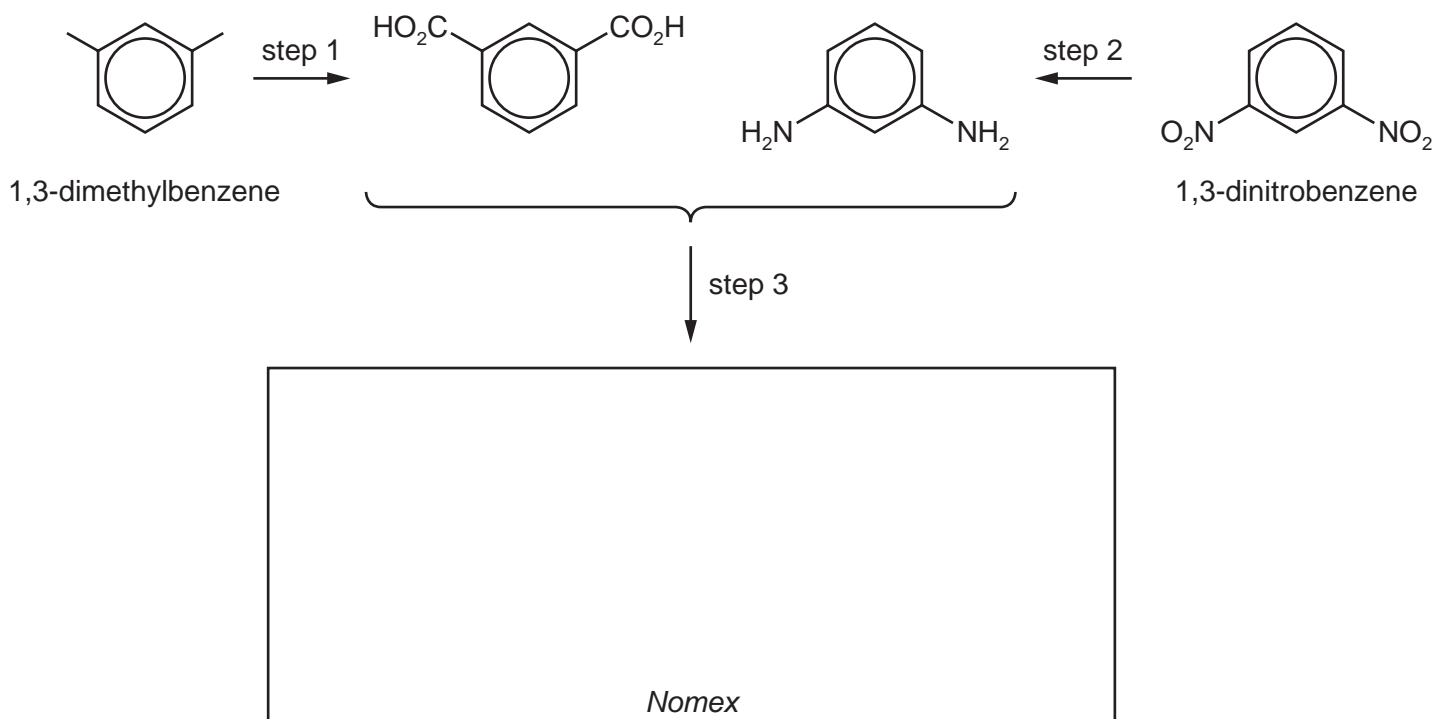
(iii) State the reagents and conditions needed for step 3.

..... [1]

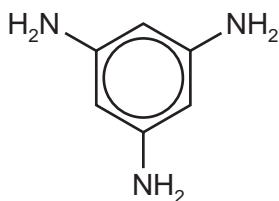
(iv) Suggest the structures of the two products formed when **A** is reacted with alkaline aqueous iodine.

[2]

- (b) 1,3-dimethylbenzene is also a starting material for the synthesis of the polymer *Nomex*, used in fireproof protective clothing worn by firefighters, military pilots and racing car drivers. The polymer is made from 1,3-dimethylbenzene and 1,3-dinitrobenzene by the following route.



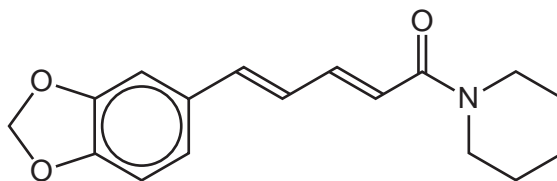
- (i) Draw the structure of one repeat unit of *Nomex* in the box above. [1]
- (ii) What type of polymer is *Nomex*? [1]  
 .....
- (iii) Suggest the by-product formed during step 3. [1]  
 .....
- (iv) Suggest reagents and conditions for step 2. [1]  
 .....
- (v) Suggest how and why the properties of the polymer might change if some of the diamine monomer were replaced with 1,3,5-triaminobenzene.



1,3,5-triaminobenzene

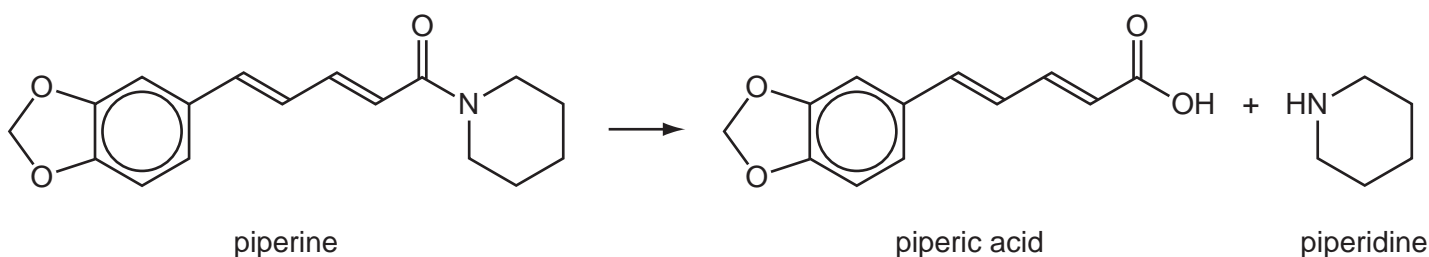
..... [1]  
 .....

- 2 Piperine is the compound responsible for the hot taste of black pepper.



piperine

Piperine is an amide and can be broken down as follows:



- (a) Suggest reagents and conditions for this reaction.

..... [1]

- (b) How many stereoisomers are there with the same structural formula as piperic acid (including piperic acid itself)?

.....

- (ii) Draw the skeletal structure of a stereoisomer of piperic acid, different to the one shown above.

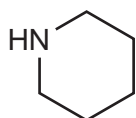
- (iii) Suggest structures for the compounds that would be formed when piperic acid is treated with an **excess** of hot concentrated acidified  $\text{KMnO}_4$ .

(c) Write the expression for  $K_w$ .

.....

(ii) Use your expression and the value of  $K_w$  in the *Data Booklet* to calculate the pH of  $0.150 \text{ mol dm}^{-3} \text{ NaOH(aq)}$ .

(iii) The pH of a  $0.150 \text{ mol dm}^{-3}$  solution of piperidine is 11.9.



piperidine

Suggest why this answer differs from your answer in (c)(ii).

.....

.....

(iv) How would you expect the basicity of piperidine to compare to that of ammonia? Explain your reasoning.

.....

.....

(d) 20.0 cm<sup>3</sup> of 0.100 mol dm<sup>-3</sup> HCl was slowly added to a 10.0 cm<sup>3</sup> sample of 0.150 mol dm<sup>-3</sup> piperidine. The pH was measured throughout the addition.

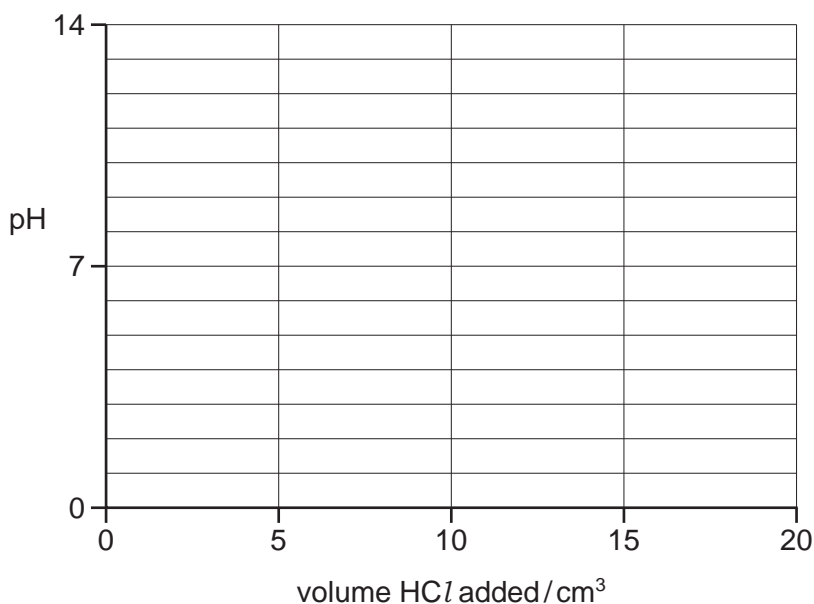
(i) Calculate the number of moles of HCl remaining at the end of the addition.

moles of HCl = .....

(ii) Hence calculate the [H<sup>+</sup>] and the pH at the end of the addition.

pH = .....

(iii) On the following axes, sketch how the pH will change during the addition of a total of 20.0 cm<sup>3</sup> of 0.100 mol dm<sup>-3</sup> HCl. Mark clearly where the end point occurs.



(iv) From the following list of indicators, put a tick in the box by the side of the indicator most suitable for this titration.

indicator	pH at which colour changes	place <b>one tick only</b> in this column
A	0-1	
B	3-4	
C	11-12	
D	13-14	

[6]

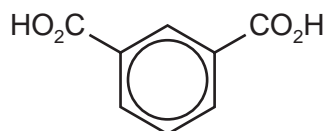
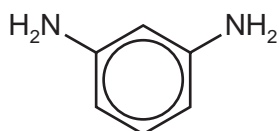
[Total: 16]

- 3 (a) Polymers can be formed by addition or condensation polymerisation. Complete the table.

polymer	method of polymerisation
nylon	
PVC (polychloroethene)	
<i>Terylene</i>	

[1]

- (b) *Nomex* is a polymeric material with excellent flame-resistant properties. It contains a polymer made from the two monomers shown below.



Draw the structure of the polymer showing **two** repeat units. The linkages between monomer units should be shown fully displayed.

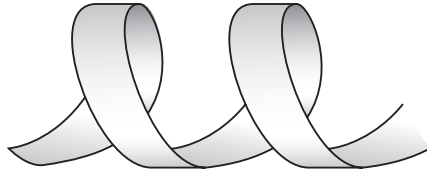
[2]

- (c) Proteins are natural polymers. Explain what is meant by the *primary structure* of a protein.

.....  
 .....  
 .....

[1]

- (d) Use the diagram to show an example of how the  $\alpha$ -helix secondary structure in proteins is stabilised.



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

- (e) The tertiary structure of a protein is destroyed during the process of denaturation. Explain how this can occur by

(i) the addition of alkali,

.....  
.....

(ii) the addition of  $\text{Hg}^{2+}$  ions,

.....  
.....

(iii) heating to  $70^\circ\text{C}$ .

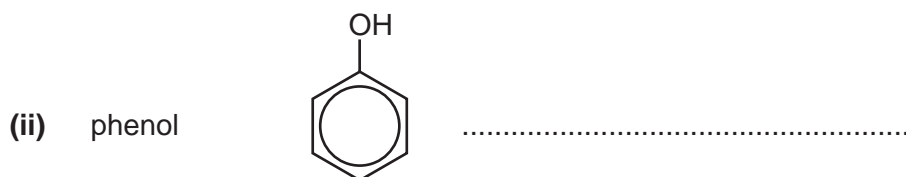
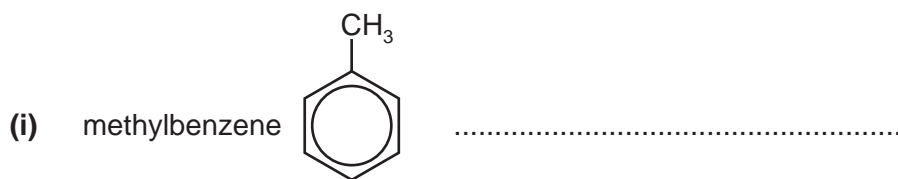
.....  
.....

[3]

[Total: 9]



- 4 (a) Describe the reagents and conditions required to form a nitro compound from the following.

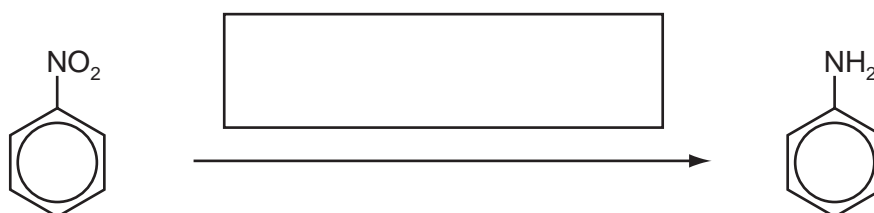


[3]

- (b) Draw the structure of the intermediate organic ion formed during the nitration of benzene.

[1]

- (c) In the box over the arrow below, write the reagents needed to convert nitrobenzene into phenylamine.

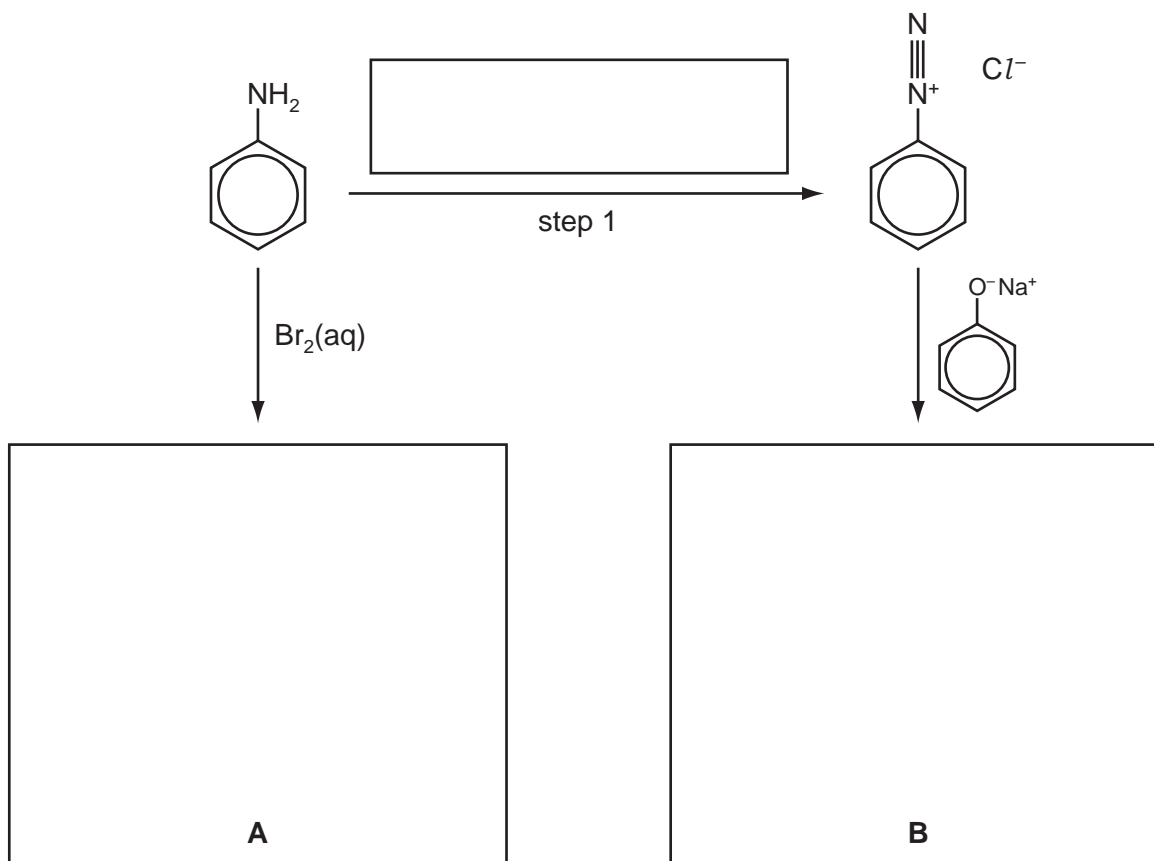


[1]

(d) Phenylamine can be converted into the organic compounds **A** and **B**.

(i) Suggest the structural formulae of **A** and **B** in the boxes below.

(ii) Suggest suitable reagents and conditions for step 1, and write them in the box over the arrow.



[3]

(e) When phenylamine is treated with propanoyl chloride a white crystalline compound, **C**,  $C_9H_{11}NO$ , is formed.

(i) Name the functional group formed in this reaction. ....

(ii) Calculate the percentage by mass of nitrogen in **C**.

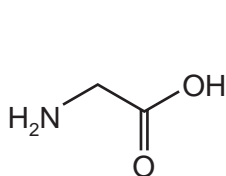
percentage = ..... %

(iii) Draw the structural formula of **C**.

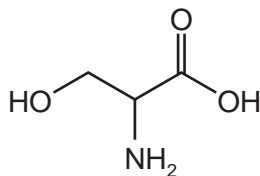
[3]

[Total: 11]

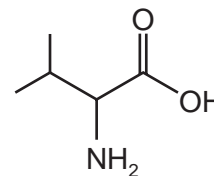
- 5 (a) Protein molecules are formed by the polymerisation of amino acids in the body. The structures of three amino acids are given.



glycine (*gly*)



serine (*ser*)



valine (*val*)

- (i) How many different tripeptides can be made using **one** molecule of **each** of the amino acids shown?

.....

- (ii) Draw the tripeptide *ser-gly-val*, showing the peptide bonds in displayed form.

- (iii) Within the tripeptide, which amino acid provides a hydrophobic side chain?

.....

- (iv) Polypeptide chains can form bonds giving proteins their *secondary* and *tertiary* structures.

Using the tripeptide in (ii), state **two** types of bonding that can be formed and the groups in the tripeptide that are involved in this bonding.

bond ..... groups .....

bond ..... groups .....

[6]

(b) Enzymes are particular types of proteins that catalyse chemical reactions. The efficiency of enzymes can be reduced by the presence of other molecules known as inhibitors. Explain how both *competitive* and *non-competitive* inhibitors prevent enzymes from working efficiently.

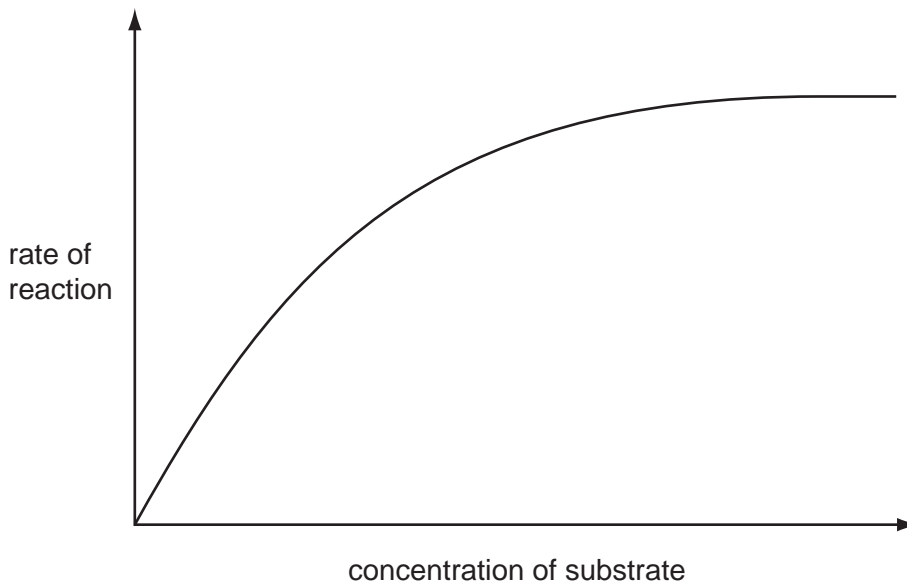
(i) competitive inhibitors .....

.....  
.....

(ii) non-competitive inhibitors .....

.....  
.....

(iii) The graph shows the rate of an enzyme-catalysed reaction against the substrate concentration in the absence of an inhibitor.



On the same axes, sketch a graph showing the rate of this reaction if a *non-competitive inhibitor* was present.

[4]

[Total: 10]