Nitrogen Compounds

Question Paper 1

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Nitrogen Compounds
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 1

Time Allowed: **68 minutes**

Score: **/56**

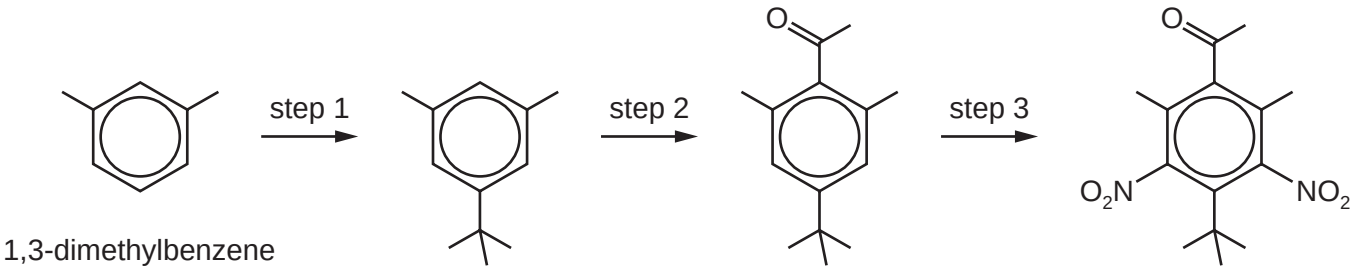
Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	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.



1,3-dimethylbenzene

'musk ketone' **A**

(i) The only by-product of step 2 is HC*l*.

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]

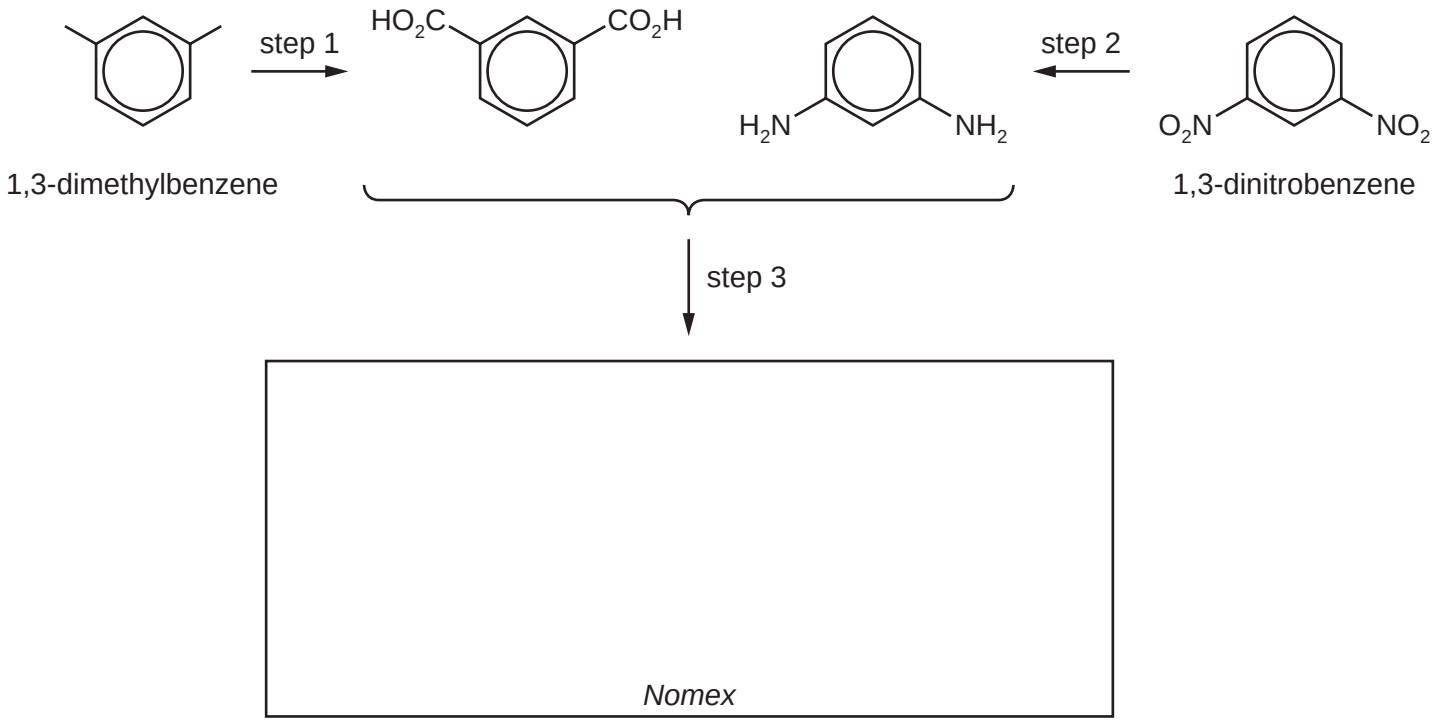
(iii) State the reagents and conditions needed for step 3.

..... [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]

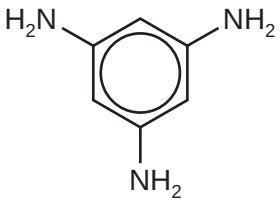
(iii) Suggest the by-product formed during step 3.

..... [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.



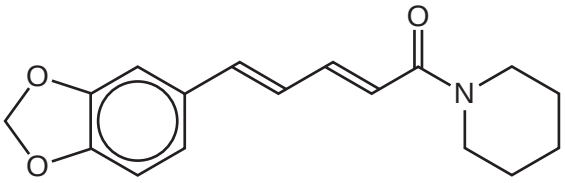
1,3,5-triaminobenzene

.....

..... [1]

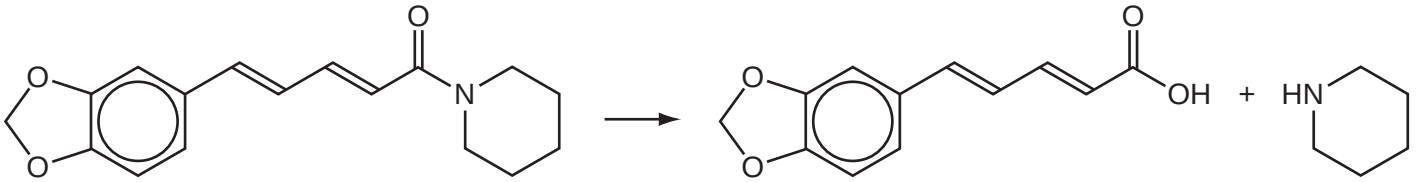
[Total: 10]

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:



piperine piperic acid piperidine

(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 $KMnO_4$.

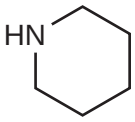
[4]

(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 mol dm^{-3} NaOH(aq).

(iii) The pH of a 0.150 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.

.....

.....

[5]

(d) 20.0 cm^3 of 0.100 mol dm^{-3} HC*l* was slowly added to a 10.0 cm^3 sample of 0.150 mol dm^{-3} piperidine. The pH was measured throughout the addition.

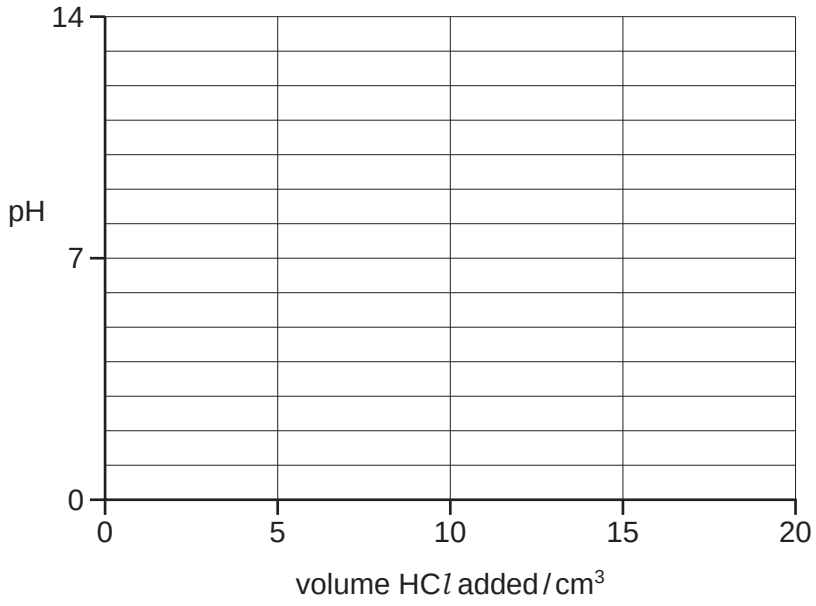
(i) Calculate the number of moles of HC*l* remaining at the end of the addition.

moles of HC*l* = ...

(ii) Hence calculate the $[H^+]$ 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^3 of 0.100 mol dm^{-3} HC*l*. 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 **one tick only** in this column
A	0 - 1	
B	3 - 4	
C	11 - 12	
D	13 - 14	

[6]

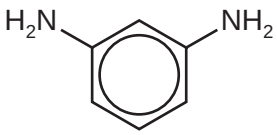
[Total: 16]

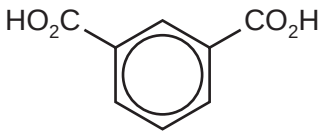
3 **(a)** Polymers can be formed by addition or condensation polymerisation.
Complete the table.

polymer	method of polymerisation
nylon	
PVC (polychloroethene)	
Terylene	

[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]

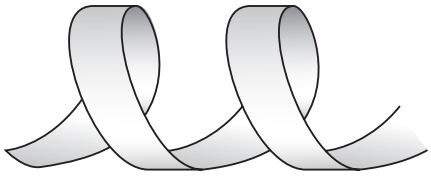
(c) Proteins are natural polymers. Explain what is meant by the *primary structure* of a protein.

.....

.....

..... [1]

(d) Use the diagram to show an example of how the **α-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 Hg^{2+} ions,

.....

.....

(iii) heating to 70 °C.

.....

.....
[3]

[Total: 9]

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

(i) methylbenzene 

.....

(ii) phenol 

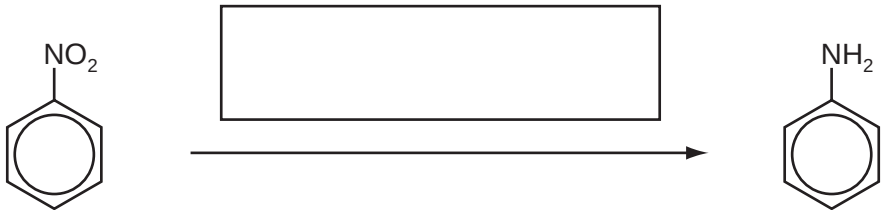
.....

[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.

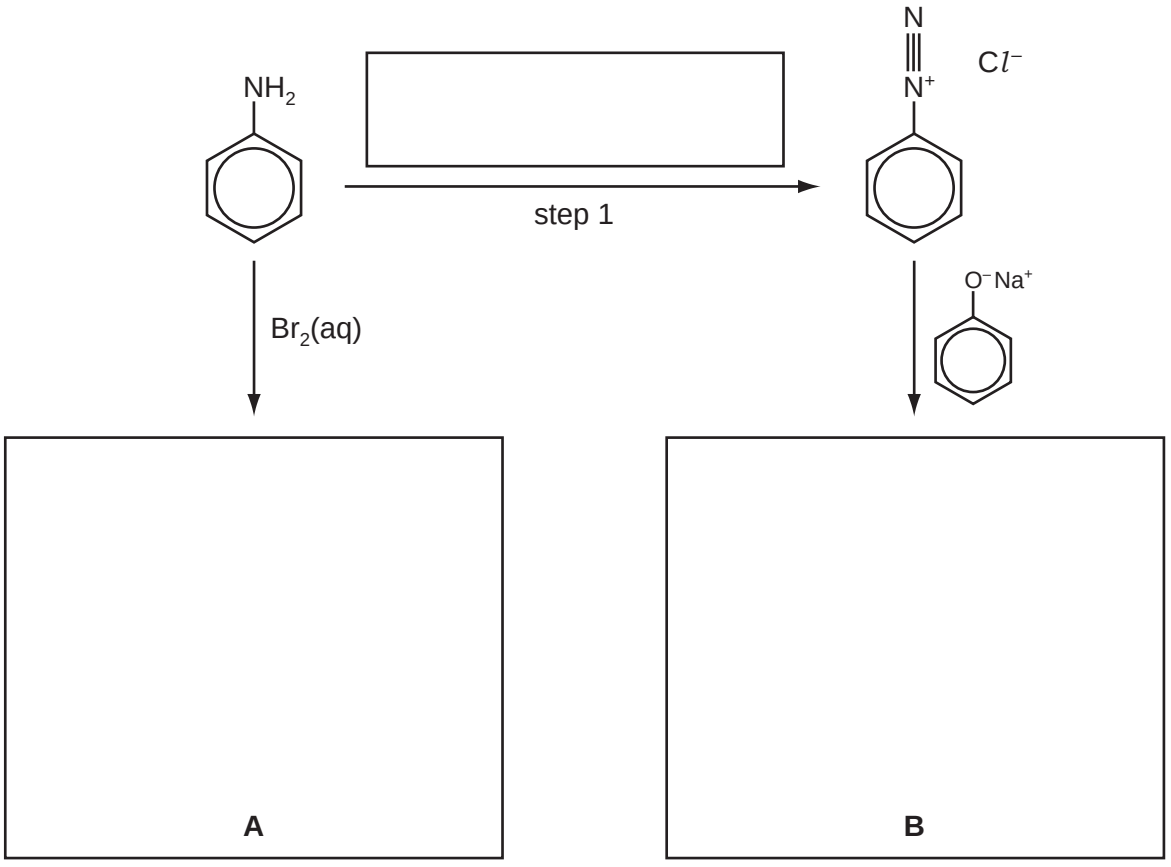


[1]

(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**.

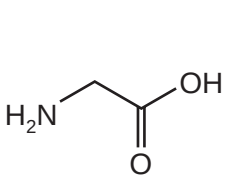
percentage = ... %

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

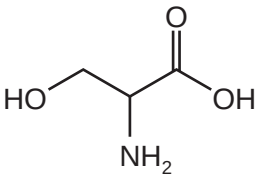
[3]

[Total: 11]

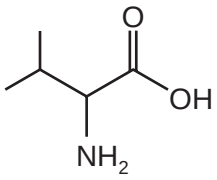
5 **(a)** Protein molecules are formed by the polymerisation of amino acids in the body. The structures of three amino acids are given.



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 .....

.....

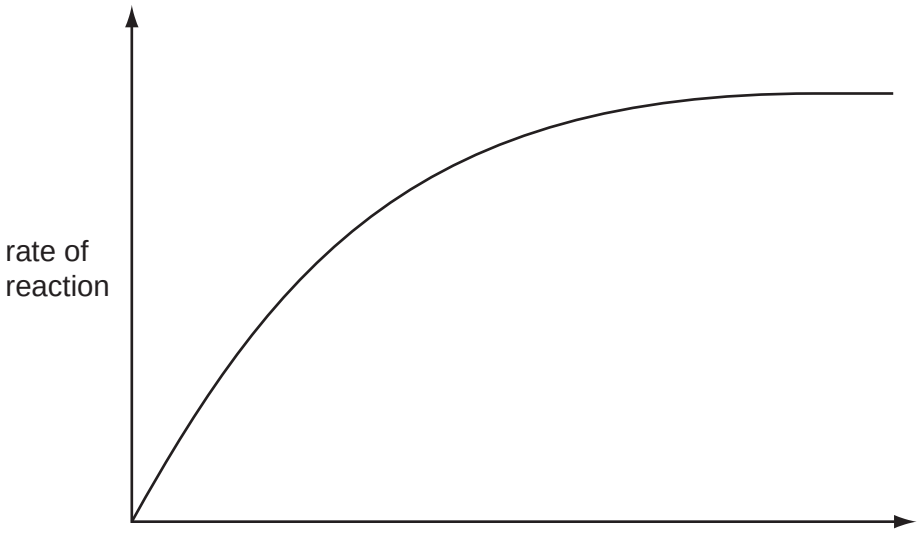
.....

(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]