

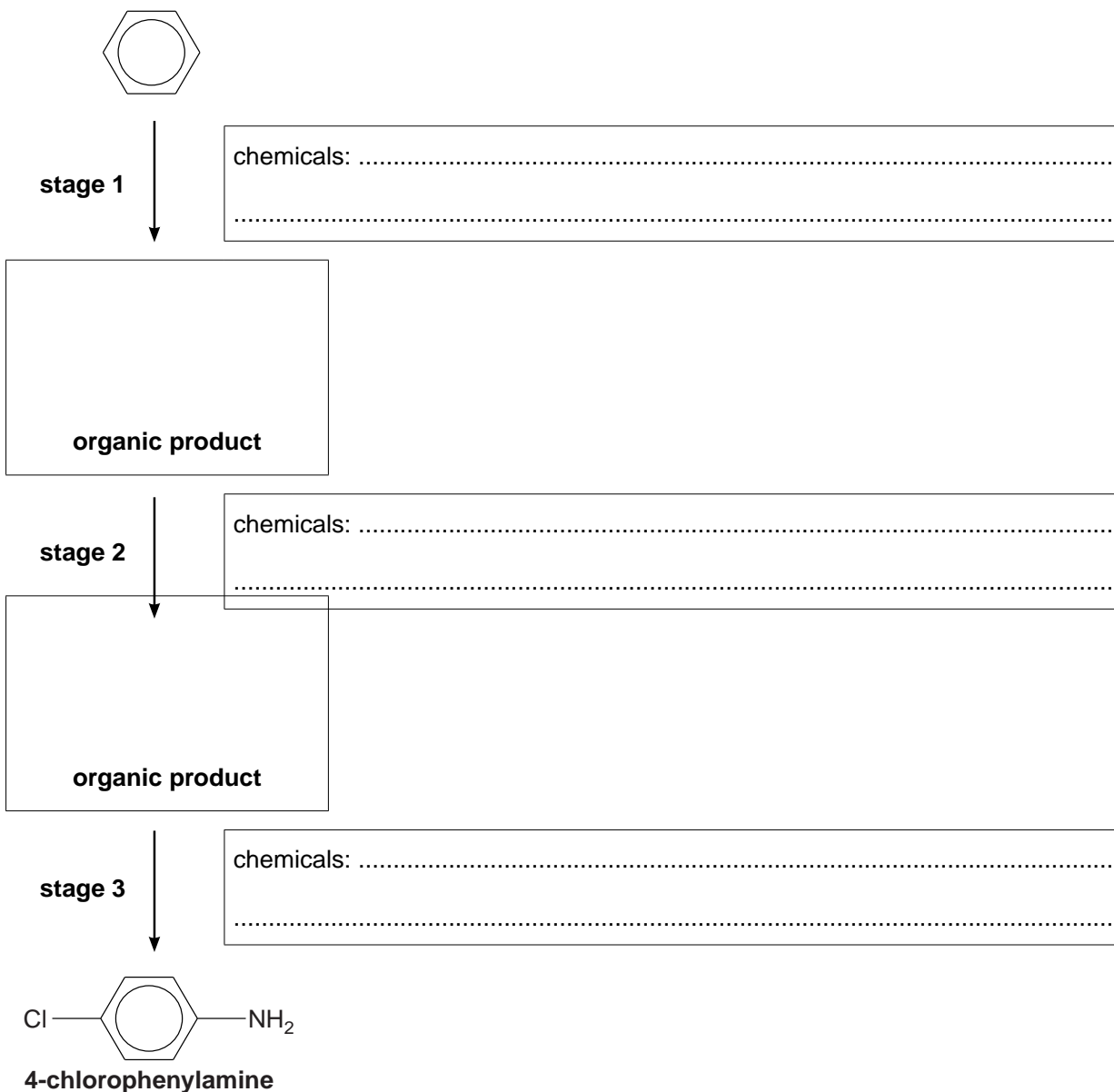
1 Benzene is an important starting material in the production of dyes, detergents and medicines.

(a) Aromatic amines, such as 4-chlorophenylamine, are intermediates in the manufacture of azo dyes.

(i) Benzene can be converted into 4-chlorophenylamine in the three stages shown below.

In the boxes

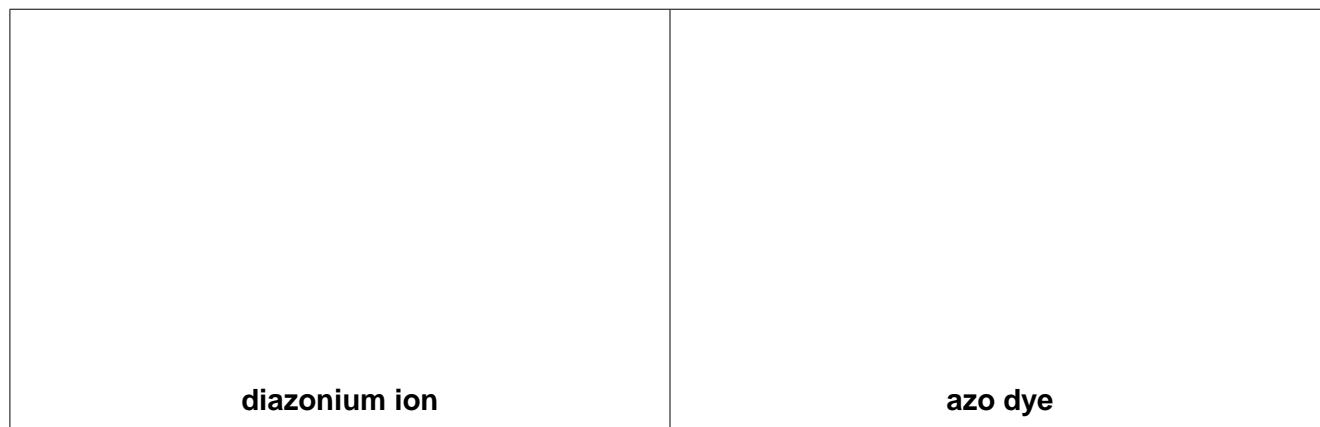
- show the structures of the organic products
- state the chemicals used.



[5]

- (ii) 4-Chlorophenylamine can be converted into a diazonium ion.
The diazonium ion can then be reacted with phenol in aqueous alkali to form an azo dye.

Draw the structures of the diazonium ion and the azo dye.

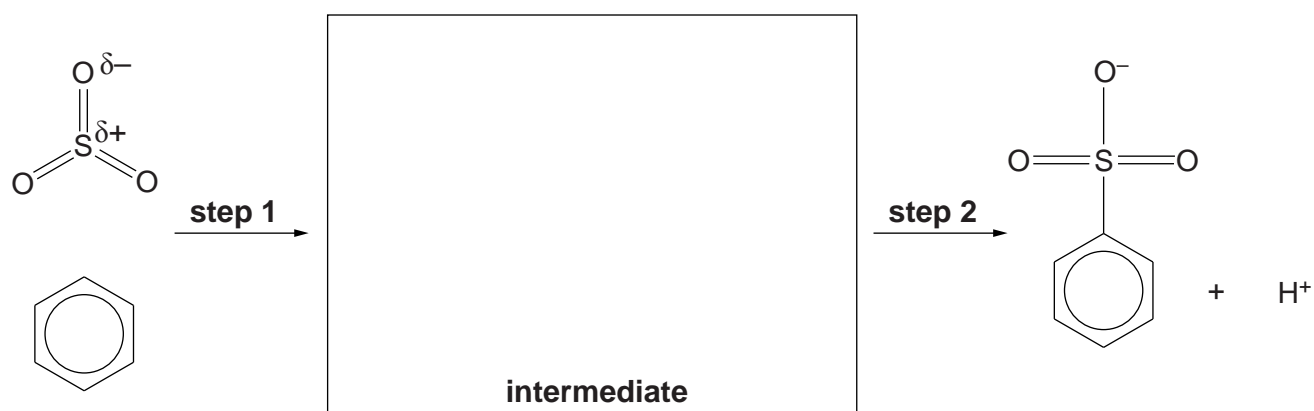


[2]

- (b) Benzene can be converted into benzenesulfonic acid, $C_6H_5SO_3H$, which is used in the manufacture of many detergents.

The reaction between benzene and sulfuric acid is an electrophilic substitution reaction.
Sulfur trioxide, SO_3 , is the electrophile.

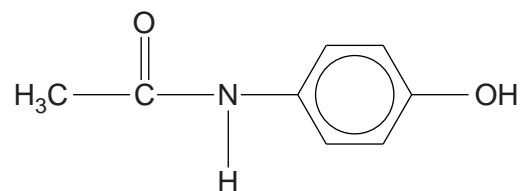
Part of the mechanism for this reaction is shown below.



Complete the mechanism by drawing the intermediate and by adding curly arrows to show the movement of electron pairs in **steps 1** and **2**.

[4]

(c) The painkiller paracetamol has the structure shown below.



(i) Separate samples of paracetamol are reacted with bromine, Br₂, and with sodium, Na.

Draw the structures of possible organic products formed in each reaction.

reaction with Br₂	reaction with Na

[2]

(ii) Another sample of paracetamol is hydrolysed by heating under reflux with hot aqueous sodium hydroxide, NaOH(aq).

Draw the structures of the two organic products formed in this hydrolysis.

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[2]

[Total: 15]

2 Benzene is an important industrial chemical and is used in a wide range of manufacturing processes. Over time our understanding of the structure and bonding of benzene has changed and various models have been proposed.

(a) In 1865, Kekulé proposed a model for the structure and bonding of benzene, but there is considerable evidence to suggest that Kekulé's model may not be correct. Scientists have proposed alternative models for the structure and bonding of benzene.

Explain the evidence that led scientists to doubt the model proposed by Kekulé.

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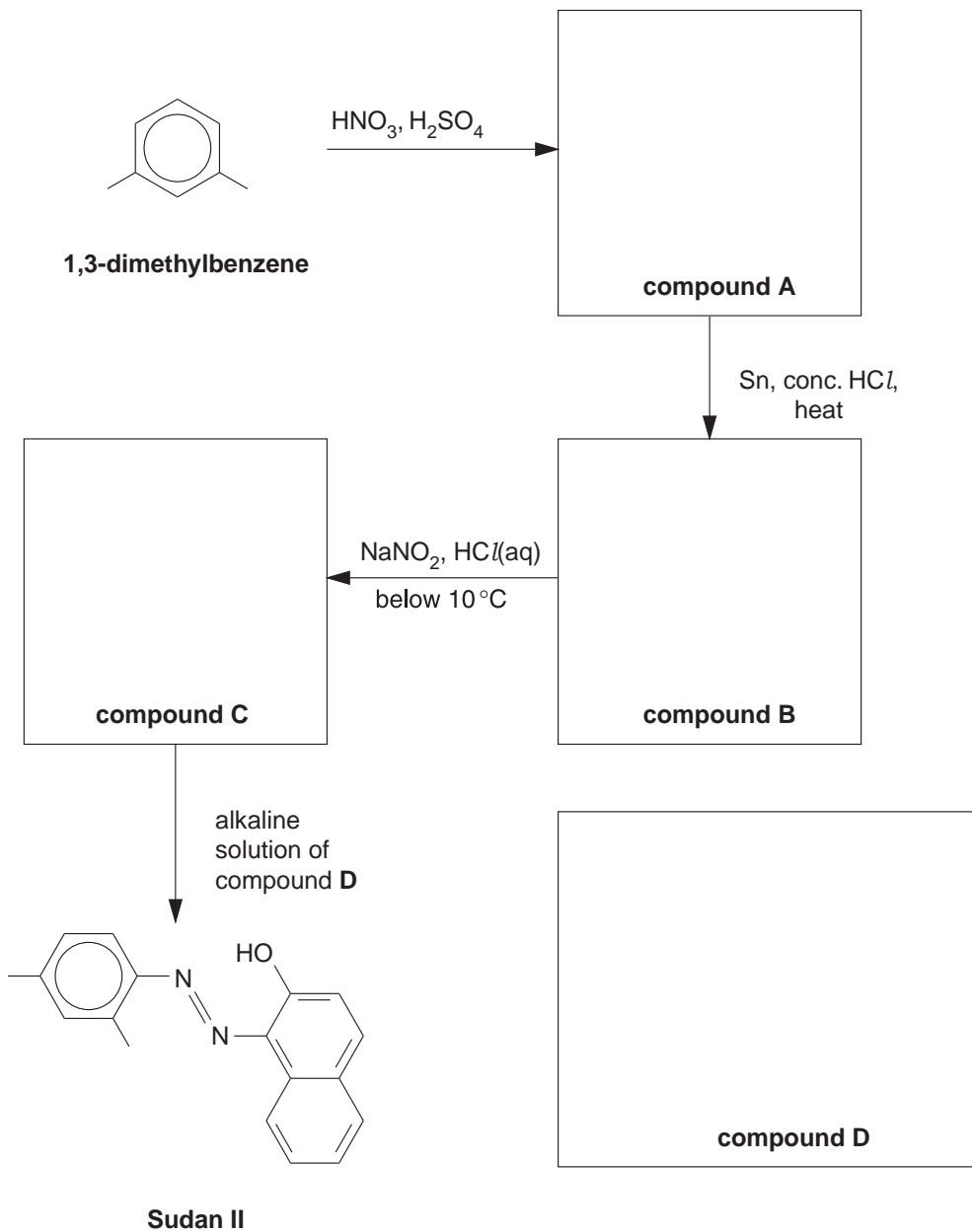
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..... **[3]**

- (b) Sudan II is an azo dye which was used as a colourant in chilli powder. However, scientists advised the Food Standards Agency that Sudan II was linked to an increased risk of cancer and it is now no longer used as a food colourant.

The flowchart below shows how Sudan II could be prepared in the laboratory from 1,3-dimethylbenzene.

- (i) Draw the structures of the organic compounds **A**, **B**, **C** and **D** in the boxes below. Display the functional group in compound **C**.



[4]

(ii) Compound **A** is formed by reacting 1,3-dimethylbenzene with HNO_3 and H_2SO_4 .

Explain, with the aid of curly arrows, the mechanism for the formation of compound **A**.

Your answer should clearly show the role of H_2SO_4 as a catalyst.

[5]

(iii) Deduce how many **other** structural isomers of compound **A** could have been formed from the mononitration of 1,3-dimethylbenzene.

..... [1]

[Total: 13]

3 A chemist was investigating the reactions of benzene, phenol and cyclohexene with bromine. She found that they all reacted with bromine but under different conditions.

(a) The chemist found that when benzene reacts with bromine, a halogen carrier is required as a catalyst.

Write an equation for this reaction.

You do **not** need to show the halogen carrier in your equation.

[1]

(b) The chemist also found that when phenol or cyclohexene reacts with bromine, a halogen carrier is **not** required.

(i) The chemist observed that bromine decolourises when it reacts with phenol.

What other observation would she have made?

Draw the structure of the organic product formed.

Observation.....

Organic product:

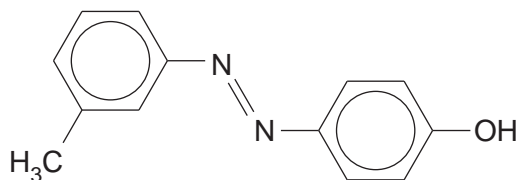
[2]

(ii) Cyclohexene also decolourises bromine.

Name the organic product formed.

..... [1]

- (c) Compound **A**, shown below, is being considered as an azo dye by a chemical company. A chemist planned a two-stage synthesis of compound **A** starting from an aromatic amine.



compound A

The aromatic amine is first converted into a diazonium ion.

- Draw the displayed formula of the aromatic amine **and** of the diazonium ion.
- State the reagents and conditions for each stage in the synthesis of compound **A** from an aromatic amine.

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..... [5]

[Total: 14]