Aromatic Compounds
AS & A Level

Question Paper 1

Level	A Level
Subject	Chemistry
Exam Board	OCR
Module	Organic Chemistry & Analysis
Topic	Aromatic Compounds
Paper	AS & A Level
Booklet	Question Paper 1

Time allowed: **100 minutes**

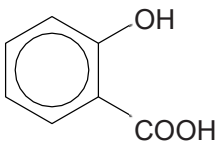
Score: **/74**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>85%	73%	60%	47%	34%	21%

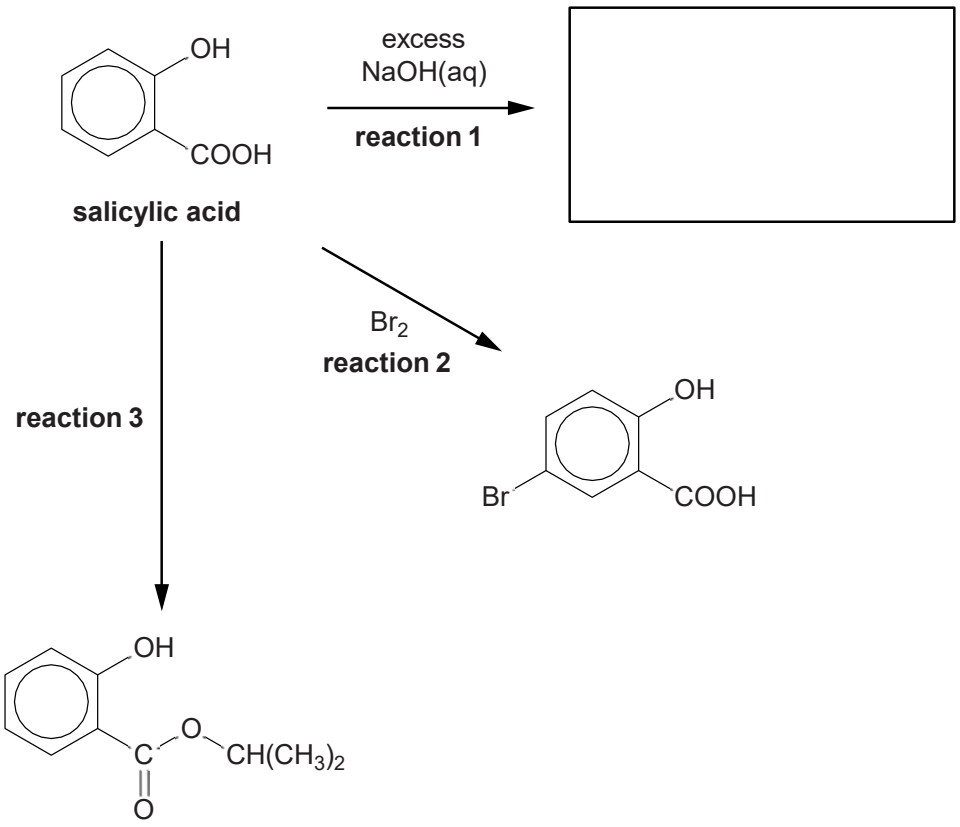
Salicylic acid is a naturally occurring carboxylic acid, widely used in organic synthesis.



salicylic acid

(a) The flowchart below shows some reactions of salicylic acid.

(i) In the box below, draw the structure of the organic compound formed by **reaction 1**. [1]



(ii) Describe what would be **observed** during **reaction 2**. [1]

(iii) Write a chemical equation to represent **reaction 2**. [1]

(iv) State the reagents and conditions in **reaction 3**. [1]

(b) Bromine reacts more readily with salicylic acid than with benzene.

(i) Outline the mechanism for the bromination of salicylic acid shown in **reaction 2** in the flowchart.

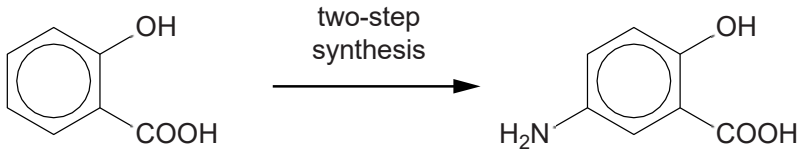
A halogen carrier is not required for this reaction.

The electrophile is Br_2. [4]

(ii) Explain why bromine reacts more readily with salicylic acid than with benzene.

In your answer, you should use appropriate technical terms, spelled correctly. [3]

(c) Mesalazine is a drug that can be synthesised from salicylic acid in two steps.



salicylic acid **mesalazine**

(i) Suggest a **two-step** synthesis to prepare mesalazine from salicylic acid.

For **each** step

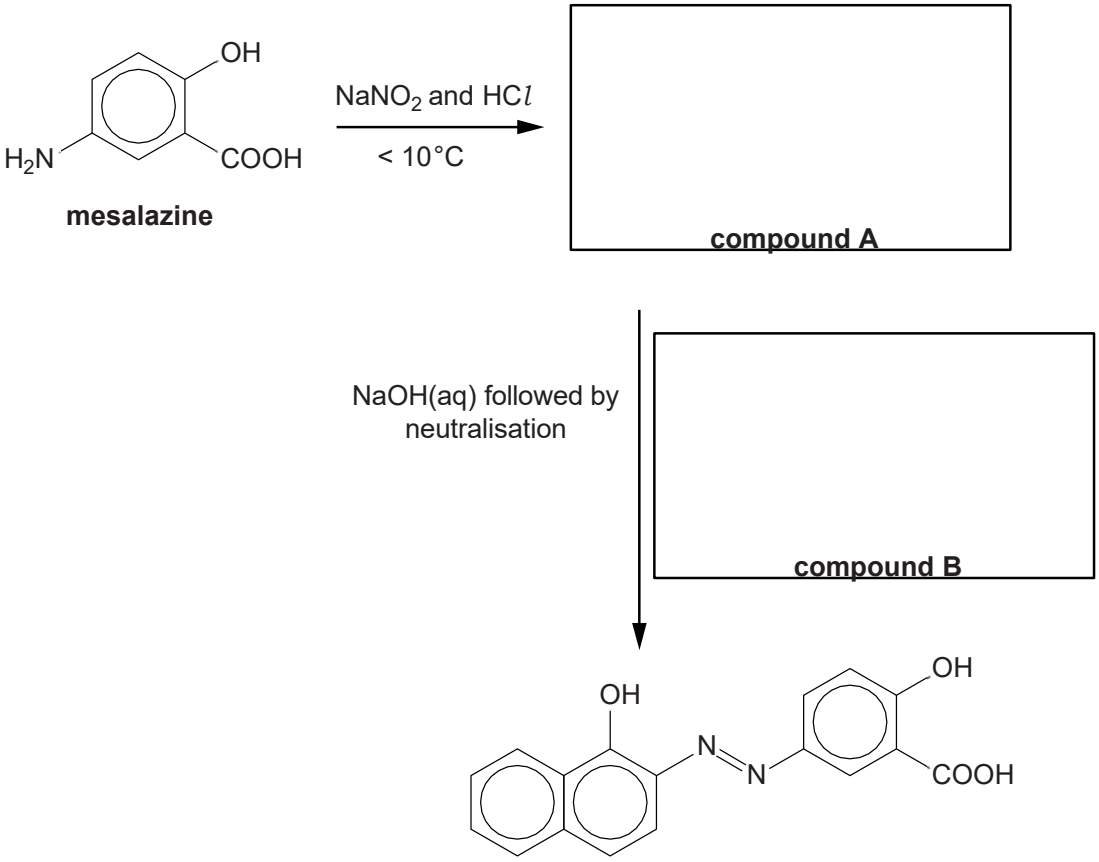
- state the reagents used,
- write a chemical equation. [4]

(ii) Mesalazine reacts with acids to form salts.

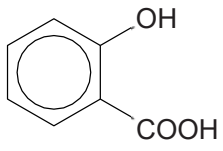
Explain how mesalazine is able to react with acids. [1]

(iii) Mesalazine reacts in another two-stage process as shown below.

In the boxes, draw the structures of organic compounds **A** and **B**. [2]



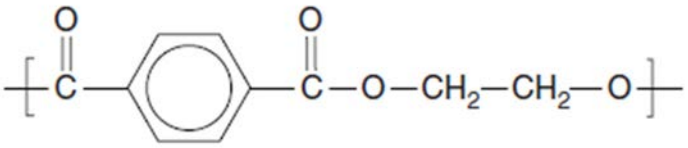
(d) Salicylic acid can be used to form a condensation polymer similar to Terylene®.



salicylic acid

(i) Explain what is meant by the term *condensation polymer*. [1]

(ii) The repeat unit of Terylene® is shown below.



Terylene®

Draw the skeletal formulae of **two** monomers that can be used to form Terylene®. [2]

(iii) Salicylic acid reacts with 3-hydroxypropanoic acid to form a mixture of condensation polymers.

To form one polymer, the two monomers react in equal quantities.

Draw the repeat unit of this polymer, displaying the link between the monomer units.

[1]

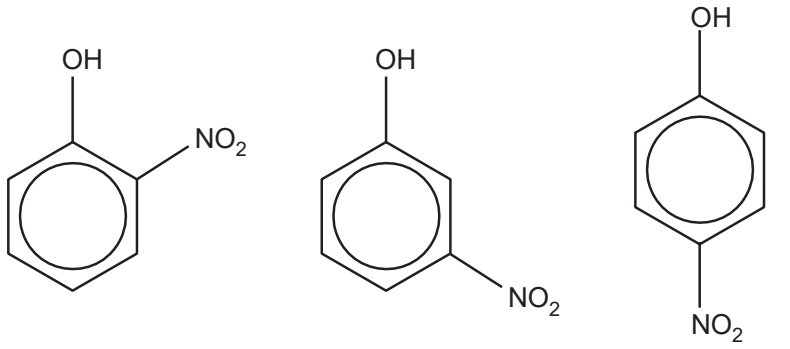
[Total 22 Marks]

This question is about aromatic compounds.

(a) Phenol undergoes nitration more readily than benzene.

(i) A student carries out the nitration of phenol with dilute nitric acid to produce 2-nitrophenol and 4-nitrophenol.

A small amount of 3-nitrophenol is also produced.



2-nitrophenol **3-nitrophenol** **4-nitrophenol**

The student thought that ^{13}C NMR spectroscopy could be used to distinguish between these three nitrophenols.

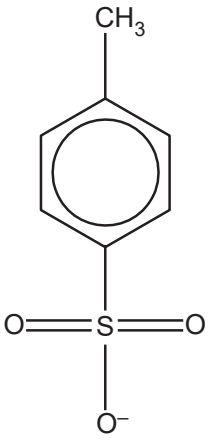
Explain whether the student is correct.

[3]

(ii) Explain why phenol is nitrated more readily than benzene.

[3]

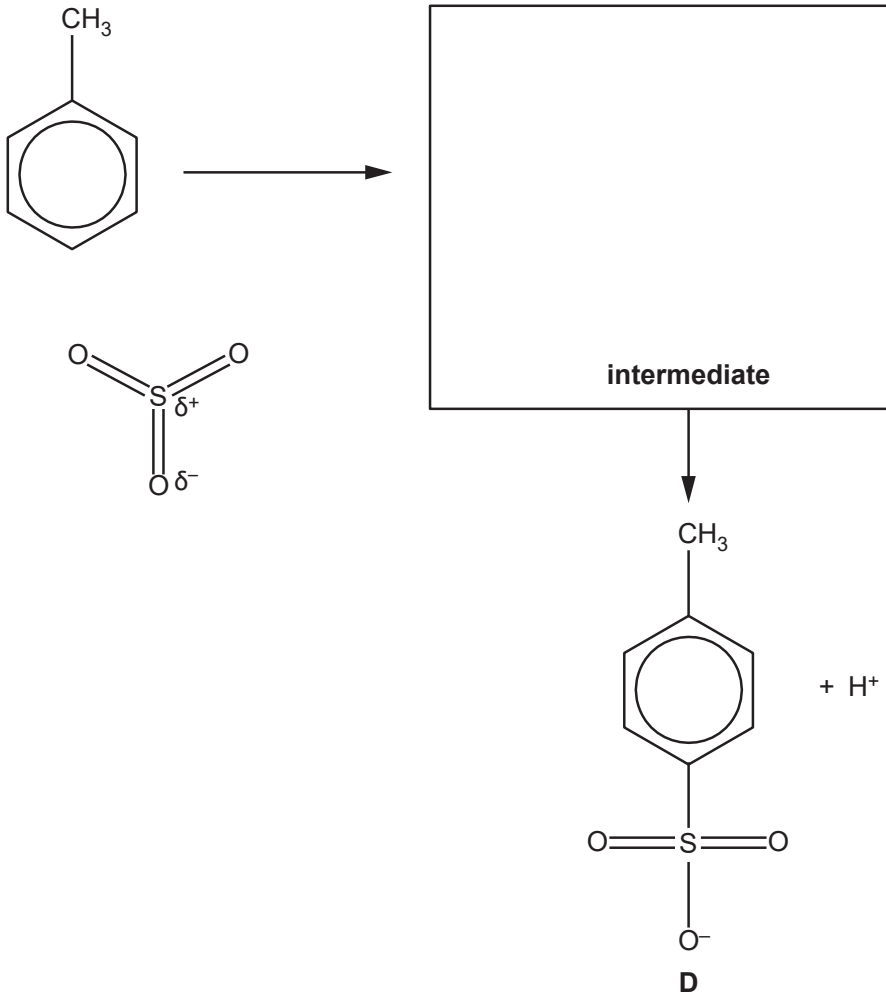
(b) Methylbenzene reacts with sulfur trioxide, SO_3, to form **D**, shown below.



D

The electrophile in this reaction is SO_3.

Complete the mechanism for the formation of **D**.
Show curly arrows and the structure of the intermediate. **[3]**



D

(Total 9 marks)

Arenes are unsaturated hydrocarbons that undergo substitution reactions.

(a) The Kekulé model and the delocalised model have been proposed for the structure and bonding of benzene.

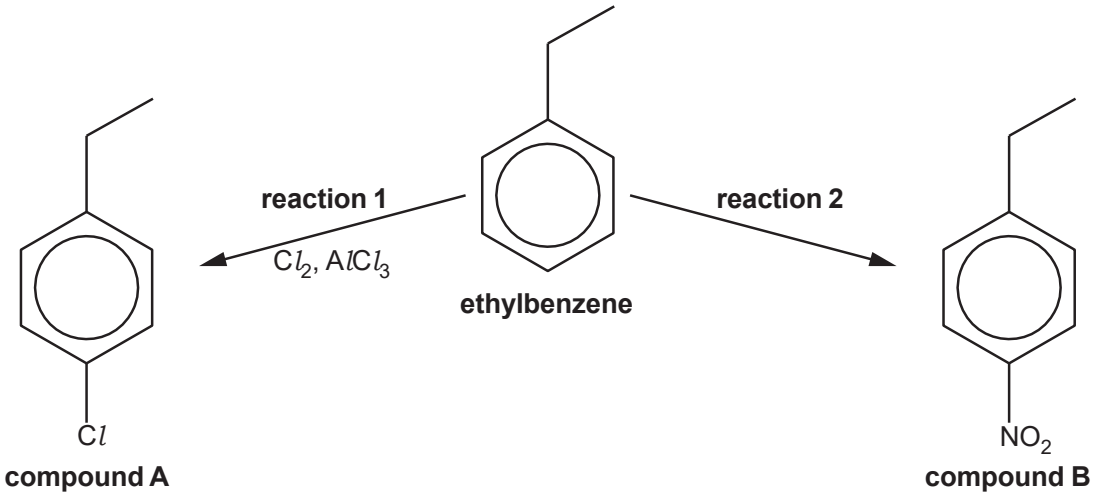
(i) Draw diagrams showing orbital overlap for the Kekulé model and the delocalised model.

[2]

(ii) Benzene is more resistant to reaction than expected from the Kekulé model.

Describe **two** other examples of experimental evidence which led scientists to doubt the model proposed by Kekulé. **[3]**

(b) The flowchart below shows the laboratory preparation of compound **A** and compound **B** from ethylbenzene. Parts **(i)**–**(iv)** refer to structures and reactions from this flowchart.



compound A **compound B**

(i) Predict the number of peaks in the carbon–13 NMR spectrum of compound **A**. . **[1]**

(ii) Compound **A** is formed in **reaction 1** by reacting ethylbenzene with chlorine in the presence of an $AlCl_3$ catalyst.

Explain, with the aid of curly arrows, the mechanism for the formation of compound **A** in **reaction 1**.

Your answer should show how $AlCl_3$ behaves as a catalyst. **[5]**

(iii) State the reagents and conditions required for the preparation of compound **B** from ethylbenzene in **reaction 2**. **[1]**

(iv) 2.65 g of ethylbenzene is converted into compound **B** in **reaction 2**.

2.31 g of compound **B** is formed.

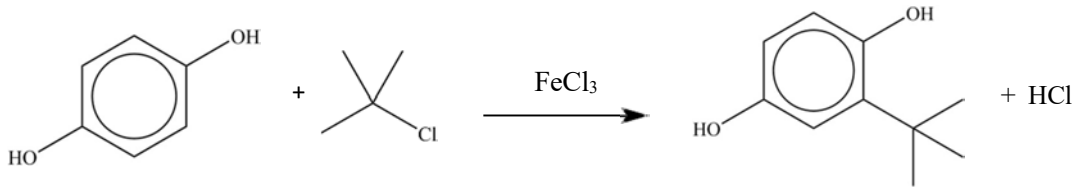
Calculate the percentage yield of compound **B**.

Give your answer to **three** significant figures. **[3]**

[Total: 15 marks]

A student investigates reactions of aromatic compounds.

(a) The student first carries out the reaction shown below.



quinol **Compound E**

(i) The student obtains a very low yield of compound **E**.
The student obtains a much higher yield of a different organic product with molecular formula $C_{14}H_{22}O_2$.

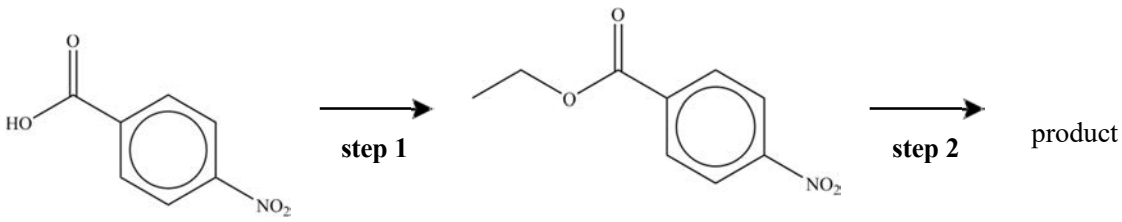
Suggest an identity for the organic product $C_{14}H_{22}O_2$ and draw its structure below. **[1]**

(ii) The student is told by a friend that the $FeCl_3$ catalyst is not needed because quinol is more reactive than benzene.

Explain why the student's friend is correct.

You may draw a diagram to support your answer. **[3]**

(b) 4-Nitrobenzoic acid is an important compound in chemical synthesis. The flowchart below shows a synthesis involving 4-nitrobenzoic acid.



Compound F

(i) State suitable reactant(s) and conditions for **step 1**. **[1]**

(ii) In **step 2**, the $-NO_2$ group in compound **F** is reduced by tin and concentrated hydrochloric acid.

Write an equation for the reduction of compound **F**. Show

the structures of any organic compounds involved.

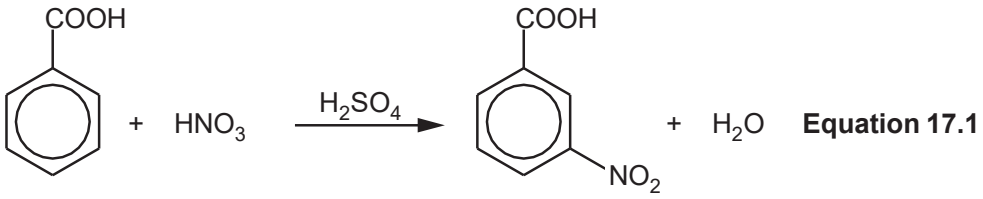
[2]

(Total 7 marks)

This question is about the chemistry of aromatic compounds.

(a) Benzoic acid can be nitrated by concentrated nitric acid in the presence of concentrated sulfuric acid as a catalyst, as shown in **Equation 17.1**.

The organic product of this reaction is 3-nitrobenzoic acid.



Equation 17.1

benzoic acid **3-nitrobenzoic acid**

(i) Outline the mechanism for this nitration of benzoic acid.

Show how H_2SO_4 behaves as a catalyst. **[5]**

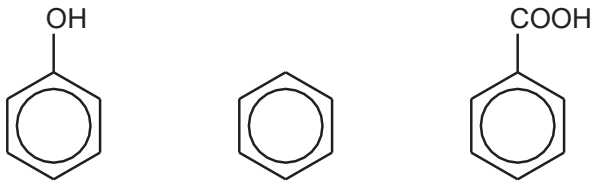
(ii)* A chemist carries out the reaction in **Equation 17.1** using 4.97 g of benzoic acid.

The chemist obtains 3-nitrobenzoic acid as an impure solid.

The chemist purifies the solid to obtain 4.85 g of 3-nitrobenzoic acid.

Describe a method to obtain a pure sample of 3-nitrobenzoic acid from the impure solid, determine the percentage yield and check its purity. **[6]**

(b) A student investigates the relative ease of nitration of phenol, benzene, and benzoic acid.



phenol **benzene** **benzoic acid**

The student finds that the conditions required for the nitration of each compound are different, as shown in **Table 17.1**.

Compound	phenol	benzene	benzoic acid
Conditions required for nitration	Dilute HNO_3 20 °C No catalyst	Concentrated HNO_3 55 °C H_2SO_4 catalyst	Concentrated HNO_3 100 °C H_2SO_4 catalyst

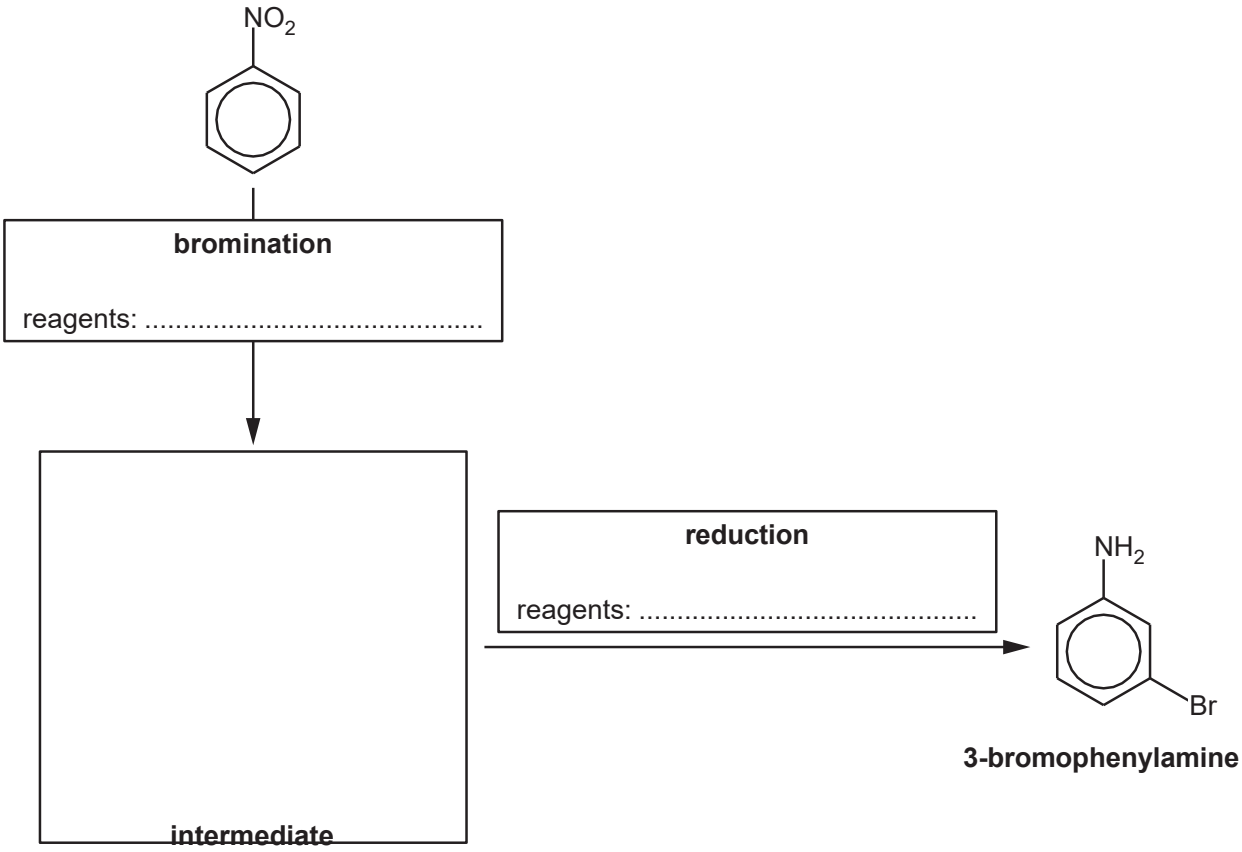
Table 17.1

(i) State the trend in the relative ease of nitration of phenol, benzene, and benzoic acid. **[1]**

(ii) Apply your knowledge of the bonding in arenes to explain the trend in part **(b)(i)**. **[3]**

(c) A student synthesises 3-bromophenylamine, shown below, starting from nitrobenzene.

(i) Complete the flowchart showing the structure of the intermediate and the **formulae** of the reagents for each stage. **[3]**



(ii) Another student attempts the same synthesis but carries out reduction **before** bromination. The student was surprised to find that two structural isomers of 3-bromophenylamine had been formed instead of the desired organic product.

Explain this result and suggest the structures of the two isomers that formed. **[3]**

(Total 21 marks)