Gold Paper
A Level only

Question Paper 2

Level	A Level
Subject	Chemistry
Exam Board	OCR
Paper	A Level only
Booklet	Question Paper 2

Time allowed: **100 minutes**

Score: **/74**

Percentage: **/100**

Grade Boundaries:

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

A buffer solution is prepared by mixing 200 cm^3 of 2.00 mol dm^{-3} propanoic acid, CH_3CH_2COOH, with 600 cm^3 of 1.00 mol dm^{-3} sodium propanoate, CH_3CH_2COONa.

K_a for CH_3CH_2COOH = 1.32 × 10^{-5} mol dm^{-3}

What is the pH of the buffer solution?

A 4.58

B 4.70

C 5.06

D 5.18

[1]

Standard electrode potentials for seven redox systems are shown in **Table 7.1**.
You may need to use this information in parts **(a)–(d)** of this question.

Redox system				$E^{\ominus}$/V
1	$Mg^{2+}(aq) + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2.37
2	$Cu^{2+}(aq) + 2e^-$	$\rightleftharpoons$	$Cu(s)$	+0.34
3	$Al^{3+}(aq) + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1.66
4	$Fe^{3+}(aq) + e^-$	$\rightleftharpoons$	$Fe^{2+}(aq)$	+0.77
5	$I_2(aq) + 2e^-$	$\rightleftharpoons$	$2I^-(aq)$	+0.54
6	$Cl_2(g) + 2e^-$	$\rightleftharpoons$	$2Cl^-(aq)$	+1.36
7	$ClO^-(aq) + 2H^+(aq) + e^-$	$\rightleftharpoons$	$\frac{1}{2}Cl_2(g) + H_2O(l)$	+1.63

Table 7.1

(a) Define the term *standard electrode potential*. Include all standard conditions in your answer. [2]

(b) An electrochemical cell can be made based on redox systems **1** and **2**.

Write down the standard cell potential of this cell. [1]

(c) Using redox systems **3**, **4** and **5 only** in **Table 7.1**, predict **three** reactions that might be feasible.

(i) Write the overall equation for each predicted reaction. [3]

(ii) Give **two** reasons why it is uncertain whether reactions predicted from $E^{\ominus}$ values may actually take place. [2]

(d) In aqueous acid, $Cl^-(aq)$ ions react with $ClO^-(aq)$ ions to form chlorine gas, $Cl_2(g)$.
In aqueous alkali, chlorine gas, $Cl_2(g)$, reacts to form $Cl^-(aq)$ and $ClO^-(aq)$ ions.

Explain this difference.
Use **Table 7.1** to help you with your answer. [4]

(e) In acidic conditions, Sn^{2+} ions react with IO_3^- ions to produce iodine and Sn^{4+} ions.

(i) What is the oxidising agent in this reaction?
Explain your answer. [1]

(ii) Construct an equation for this reaction. [2]

[Total 15 Marks]

Benzaldehyde, C_6H_5CHO, is the simplest aromatic aldehyde and has a characteristic smell of almonds.

(a) Benzaldehyde can be nitrated with a mixture of concentrated nitric acid and concentrated sulfuric acid to form 3-nitrobenzaldehyde.

Explain, with the aid of curly arrows, the mechanism for the formation of 3-nitrobenzaldehyde.

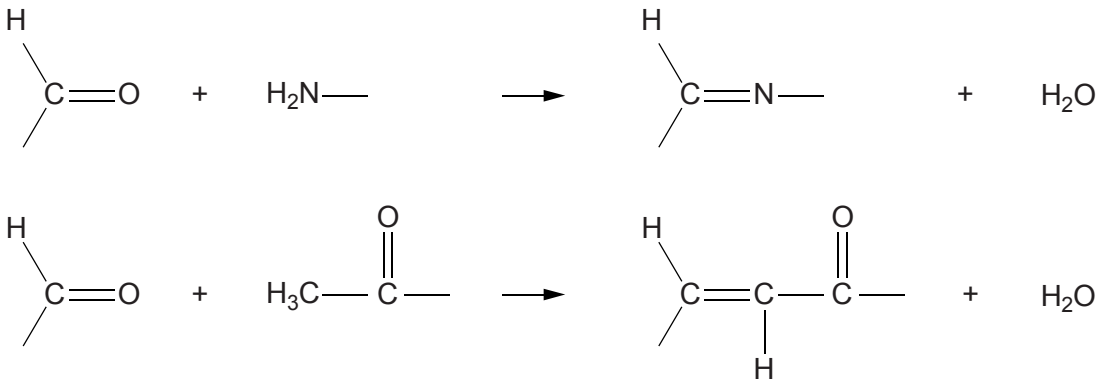
Your answer should clearly show the role of sulfuric acid as a catalyst. [6]

(b) Benzaldehyde reacts with a solution of potassium hydroxide. In this reaction, benzaldehyde is both oxidised and reduced to form two organic products.

Suggest an equation for this reaction, showing clearly the structures of the two organic products. [3]

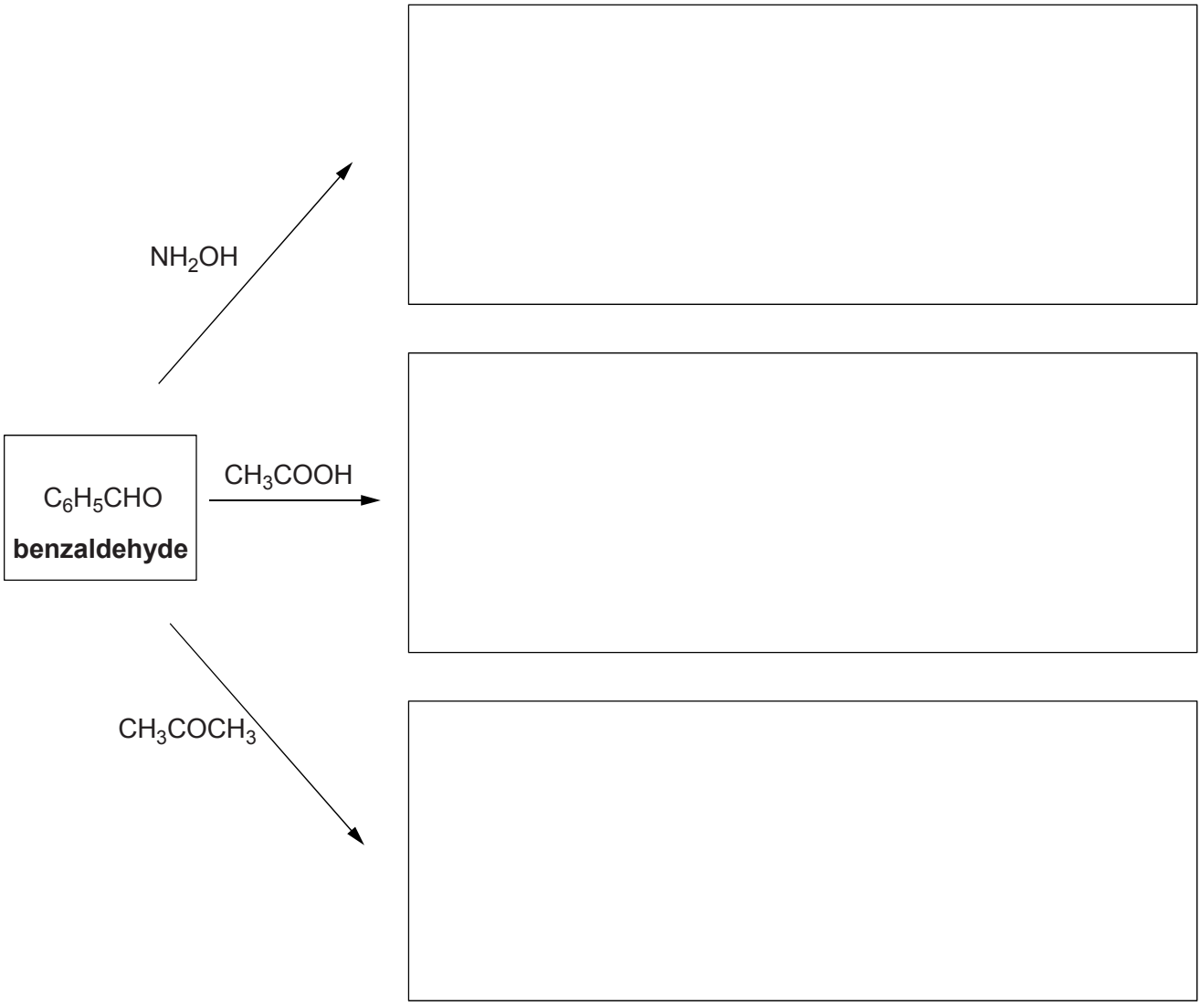
(c) The aldehyde group takes part in 'condensation' reactions with many compounds containing an amine group or a methyl group adjacent to a C=O.

In these reactions, water is formed as a product. Two examples are shown below.



Predict the organic products formed in the following condensation reactions of benzaldehyde. In each reaction, an excess of benzaldehyde is used.

Draw the structure of each organic product in the boxes.



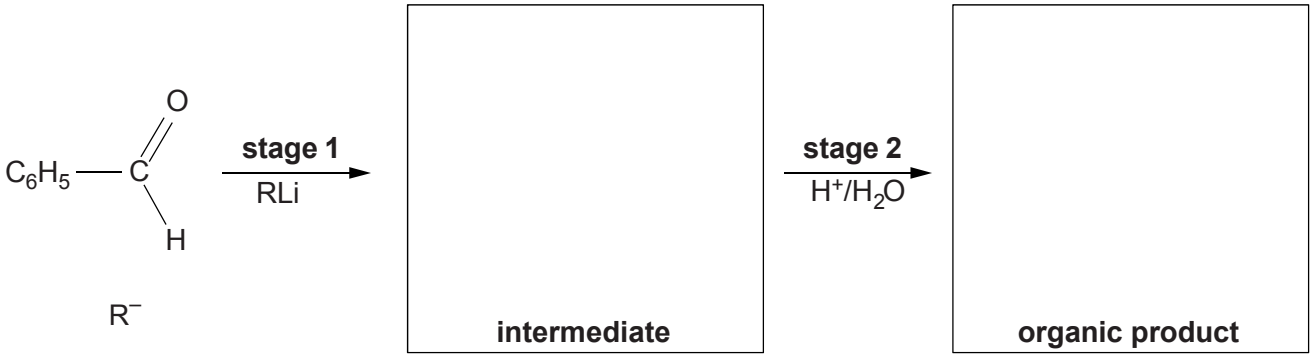
[3]

(d) Alkyllithium compounds, RLi, can be used to increase the number of carbon atoms in an organic compound. Different alkyl groups, R, add carbon chains with different chain lengths.

RLi provides a source of R^- ions, which act as a nucleophile.

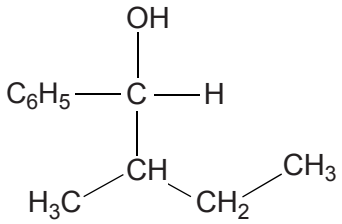
(i) The diagram below shows an incomplete mechanism for the reaction of RLi with benzaldehyde, followed by reaction with aqueous acid.

- Complete, using curly arrows and relevant dipoles, the mechanism for **stage 1**.
- Give the structure of the intermediate and the organic product.



[4]

(ii) A chemist needs to prepare the organic compound below from benzaldehyde.



Draw the structure of the alkyllithium compound needed for this synthesis. [1]

[Total 17 Marks]

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.

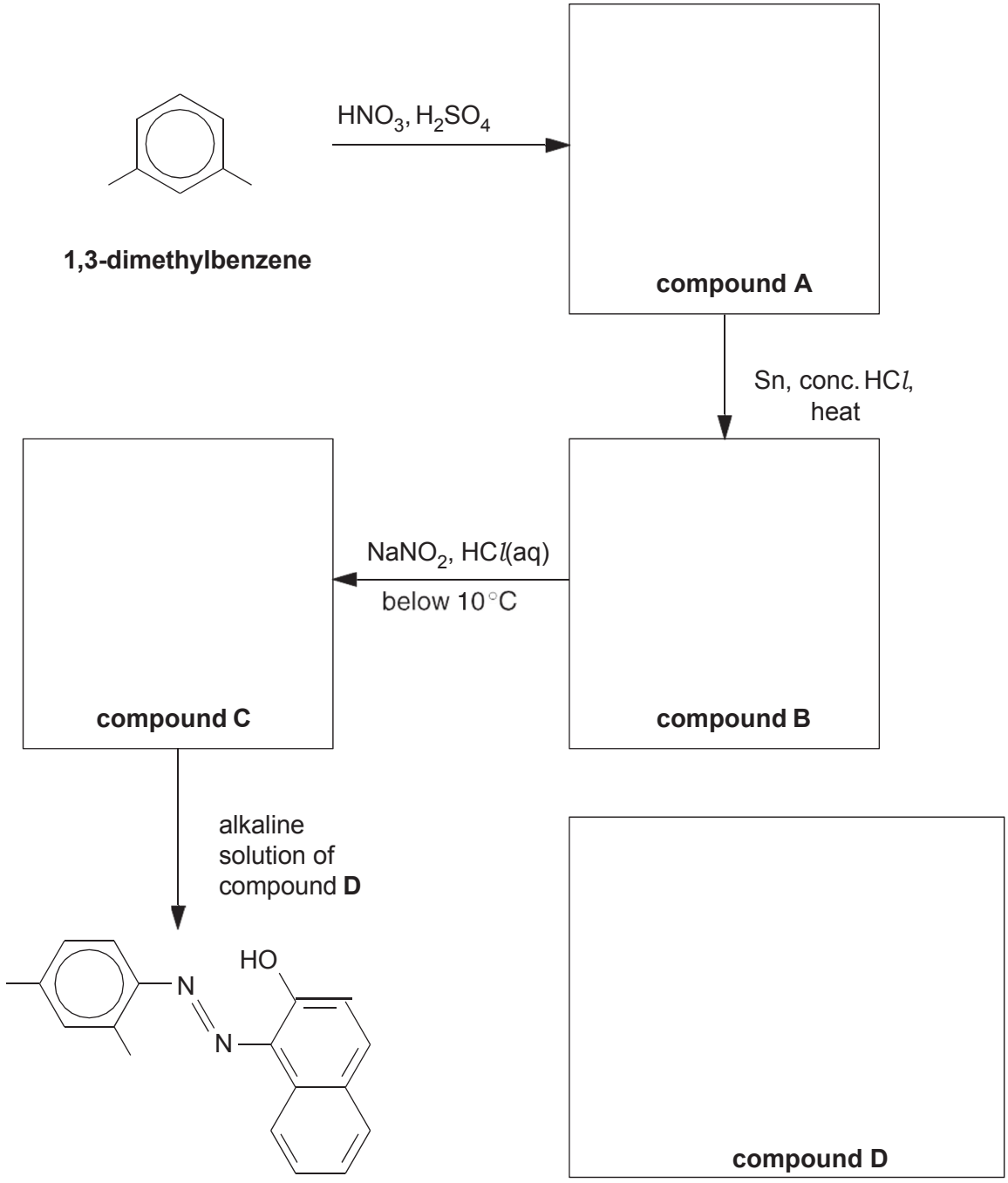
(a) In 1865, Kekulé proposed a model for the structure and bonding of benzene, but there is considerable evidence to suggest that Kekulé's model may not be correct. Scientists have proposed alternative models for the structure and bonding of benzene.

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



1,3-dimethylbenzene

Sudan II

[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.

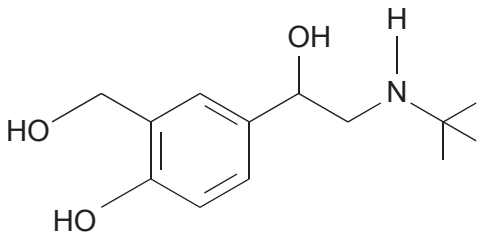
[1]

[Total 13 Marks]

Hydroxyamines are organic compounds containing hydroxyl and amino functional groups.

(a) Salbutamol is a hydoxyamine used in the treatment of asthma and bronchitis. Salbutamol is an example of a chiral drug.

(i) Draw a circle around the chiral carbon in the structure of salbutamol shown below.



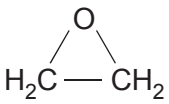
salbutamol

[1]

(ii) Suggest possible problems of making a chiral drug such as salbutamol and describe **two** ways that the pharmaceutical industry might overcome these problems. [4]

(b) Monoethanolamine, MEA, $H_2NCH_2CH_2OH$, is a hydroxyamine that is used in aqueous solution as a gas scrubber to remove acidic gases from emissions in incinerators.

MEA is prepared industrially by reacting ammonia with epoxyethane.



epoxyethane

(i) Write an equation for the industrial preparation of MEA. [1]

(ii) During the manufacture of MEA, a compound with molecular formula $C_4H_{11}NO_2$ is also formed.

Draw the structure of the compound with molecular formula $C_4H_{11}NO_2$. [1]

(c) The combustion of some polymers produces emissions containing toxic acidic gases such as HCl and H_2S. MEA can remove HCl and H_2S from the emissions.

Give the formula of the organic salts formed when MEA removes:

(i) HCl, [1]

(ii) H_2S. [1]

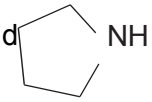
(d) MEA, $H_2NCH_2CH_2OH$, can be oxidised to form an α-amino acid.

(i) Explain what is meant by an α-amino acid. [1]

(ii) Write an equation for the oxidation of MEA to form an α-amino acid.

Use [O] to represent the oxidising agent [1]

(e) Isomers **F** and **G** are hydroxyamines each with the molecular formula $C_4H_{11}NO$.

- Isomer **F** can be dehydrated to form the cyclic compound 

- Isomer **G** has two chiral centres.

Identify and draw the structural isomers **F** and **G**.

isomer F	**isomer G**

[2]

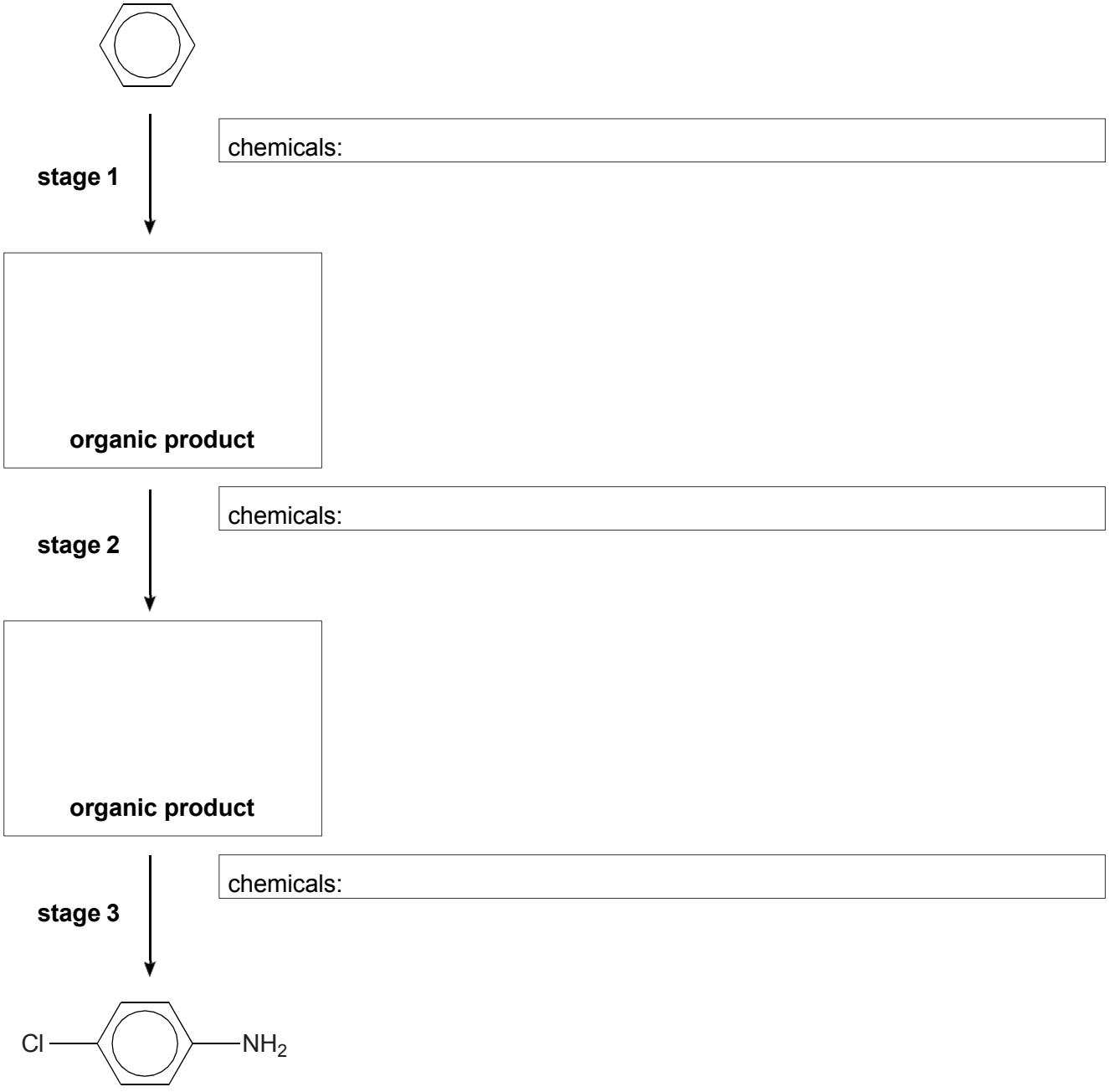
[Total 13 Marks]

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.



4-chlorophenylamine

[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.

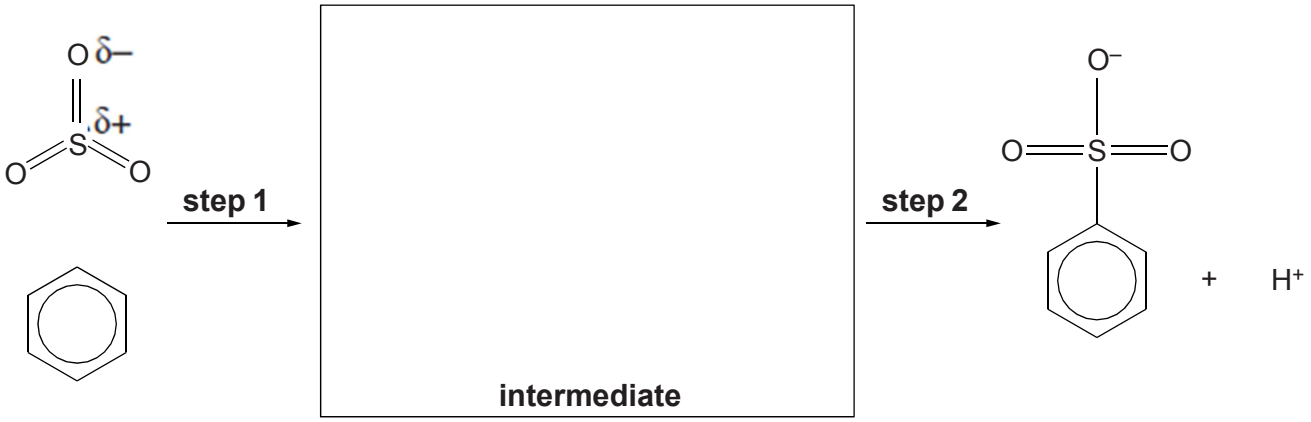
diazonium ion	azo dye

[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.

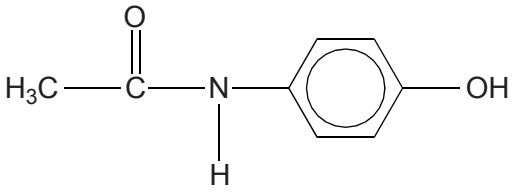
Part of the mechanism for this reaction is shown below.



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, Br_2, and with sodium, Na.

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

reaction with Br_2	**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.

[2]

[Total 15 Marks]