

Arenes

Question Paper 2

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Hydrocarbons
Sub-Topic	Arenes
Paper Type	Theory
Booklet	Question Paper 2

Time Allowed: 77 minutes

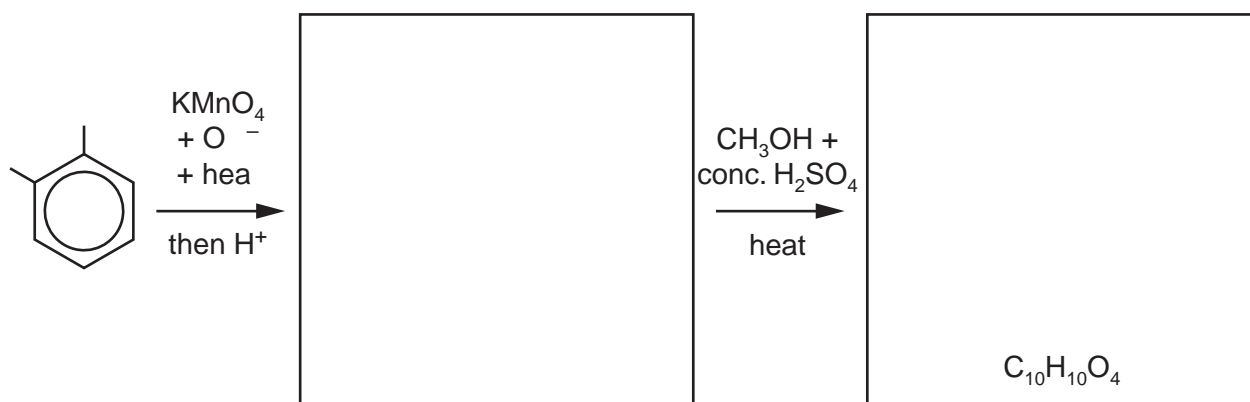
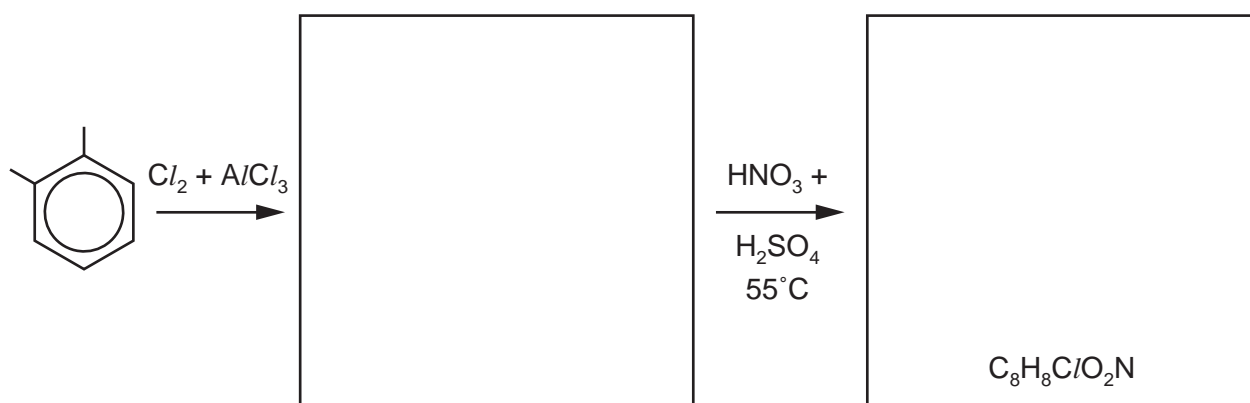
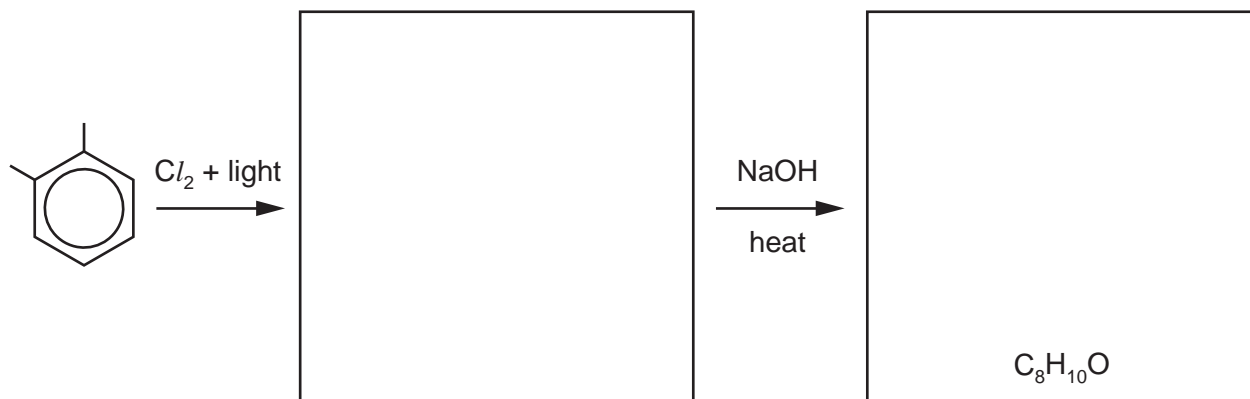
Score: /64

Percentage: /100

Grade Boundaries:

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

- 1 Predict the products of the following reactions and draw their structures in the boxes provided. Note that the molecular formula of the final product is given in each case.



[6]

[Total: 6]

2 (a) (i) Briefly explain why the benzene molecule is planar.

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

(ii) Briefly explain why all the carbon-carbon bonds in benzene are the same length.

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

[2]

(b) Benzene can be nitrated by warming it with a mixture of concentrated sulfuric and nitric acids.

(i) By means of an equation, illustrate the initial role of the sulfuric acid in this reaction.

.....

(ii) Name the type of reaction and describe the mechanism for the nitration reaction, including curly arrows showing the movement of electrons and all charges.

type of reaction

mechanism

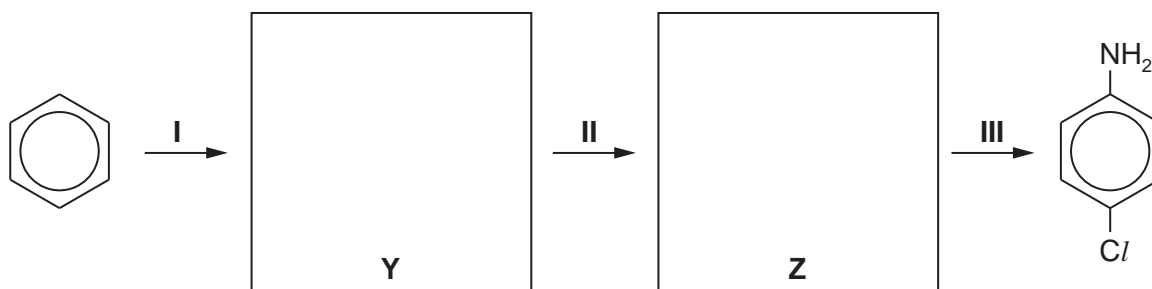
[4]

(c) State the reagents and conditions needed to convert benzene into chlorobenzene.

..... [1]

(d) Nitrobenzene undergoes further substitution considerably more slowly than chlorobenzene. In nitrobenzene the incoming group joins to the benzene ring in the 3-position, whereas in chlorobenzene the incoming group joins to the benzene ring in the 4-position.

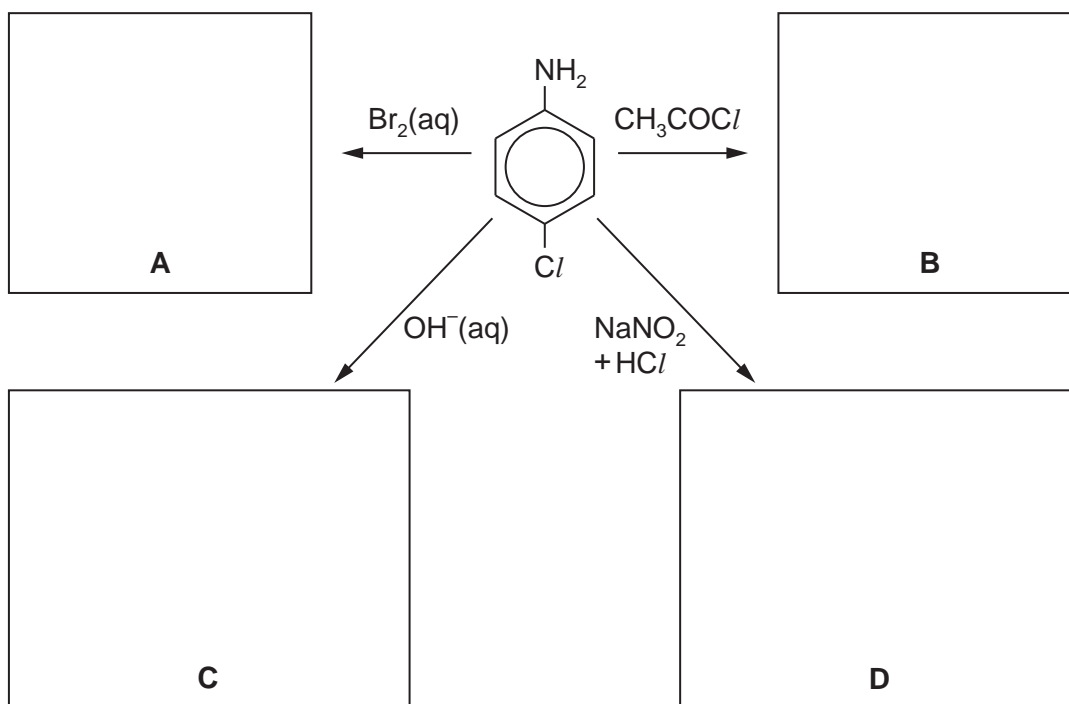
(i) Use these ideas to suggest the structures of the intermediate compounds **Y** and **Z** in the following synthesis of 4-chlorophenylamine.



(ii) Suggest the reagents and conditions needed for reaction III in the above synthesis.

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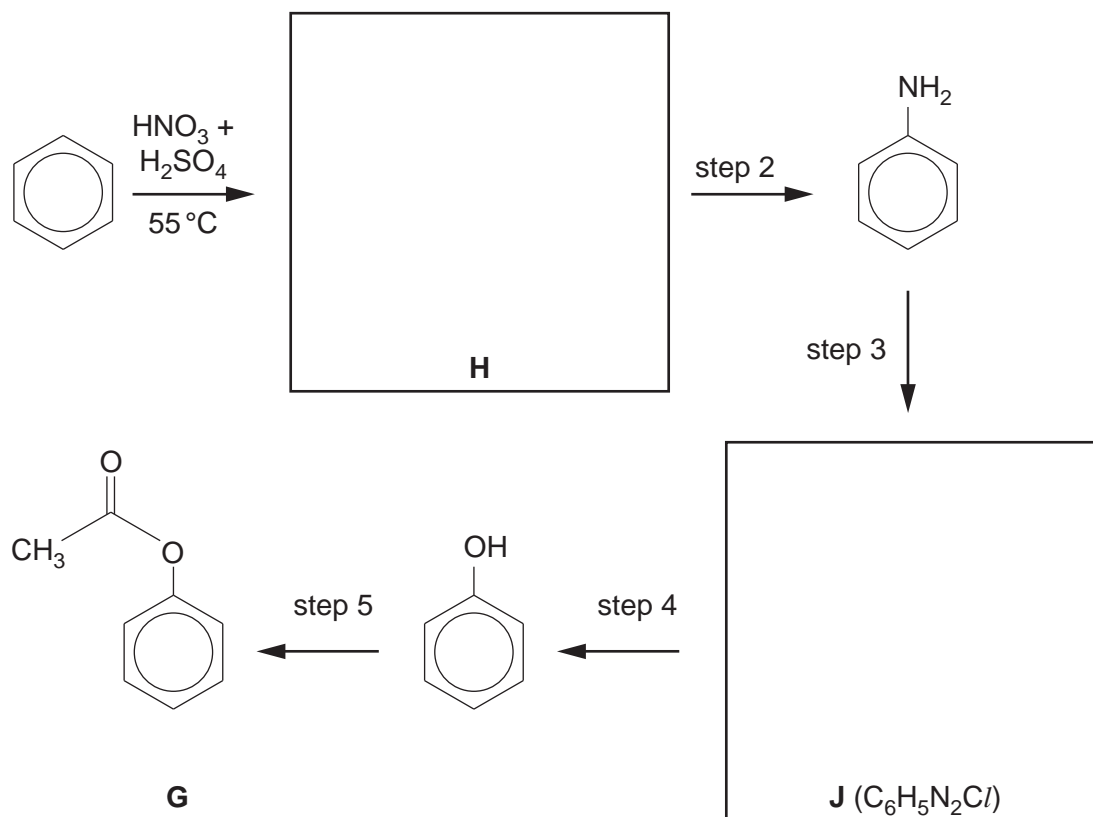
(iii) Suggest the structural formulae of the products **A**, **B**, **C** and **D** of the following reactions. If no reaction occurs write “no reaction” in the relevant box.



[8]

[Total: 15]

- 3 (a) Compound **G** can be synthesised from benzene by the route shown below.



- (i) Name the functional group formed in step 5.

.....

- (ii) Draw the structures of the intermediates **H** and **J** in the boxes above.

- (iii) Suggest reagents and conditions for the following.

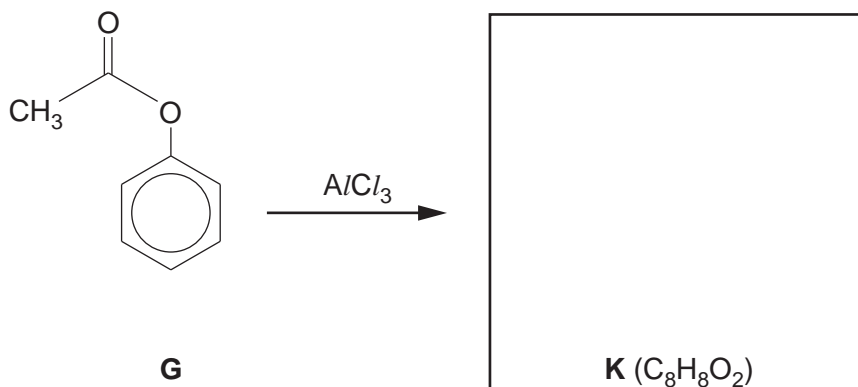
step 2

step 3

step 4

step 5

- (b) In a reaction discovered just over 100 years ago by the German chemist Karl Fries, compound **G** is converted into compound **K** when it is heated with $AlCl_3$. Compound **K** is a structural isomer of **G**.



Compound **K** is a 1,4-disubstituted benzene derivative. It is insoluble in water, but dissolves in $NaOH(aq)$. It gives a white precipitate with $Br_2(aq)$, and a yellow precipitate with alkaline aqueous iodine.

- (i) What is meant by the term *structural isomerism*?

.....

.....

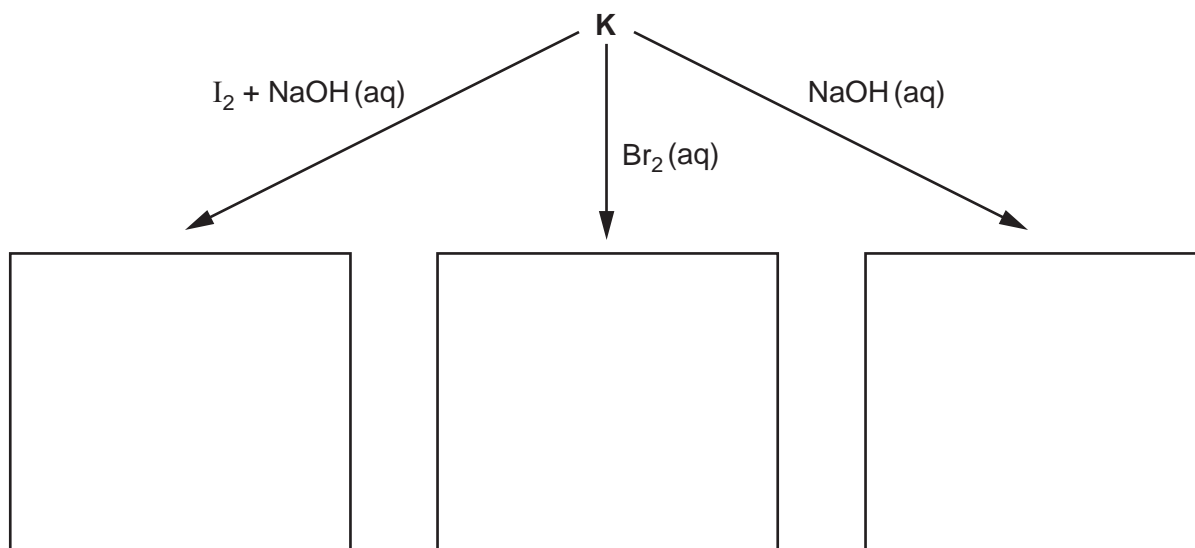
- (ii) Use the information given above to **name** two functional groups in compound **K**.

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.....

- (iii) Suggest the structural formula of **K**, and draw it in the box above.

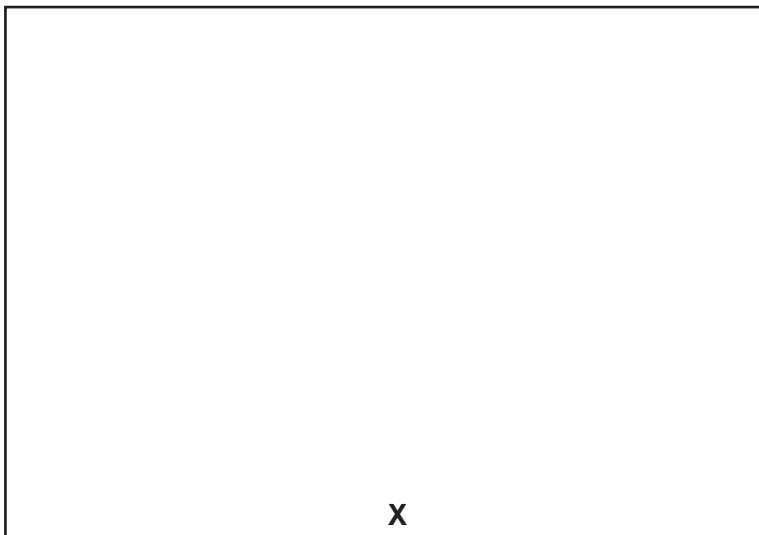
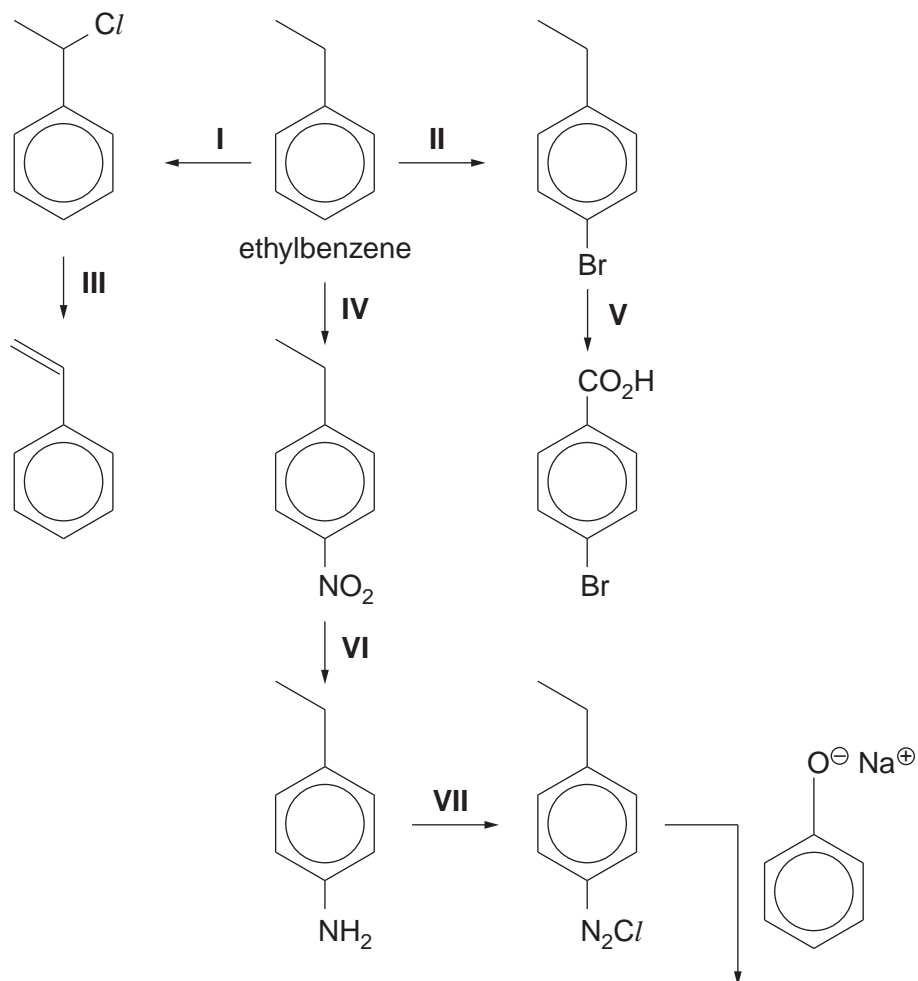
- (iv) Suggest structures for the aromatic products of the following reactions.



[7]

[Total: 14]

4 The following chart shows some reactions of ethylbenzene and compounds produced from it.



(i) Draw the structure of compound X in the box provided in the chart above.

- (ii) Suggest reagents and conditions for each of the reactions, writing them in the spaces below.

reaction I

reaction II

reaction III

reaction IV

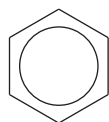
reaction V

reaction VI

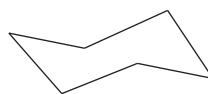
reaction VII

[Total: 8]

- 5 (a) All the carbon atoms in benzene lie in the same plane. This means that they are *coplanar*, but this is not the case with cyclohexane.

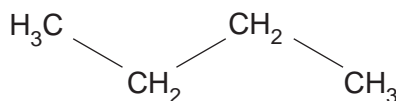


benzene

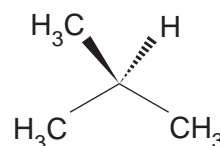


cyclohexane

By rotating the molecule around its several C–C bonds, all the carbon atoms in butane can be made to lie in the same plane, but this is not the case with methylpropane.

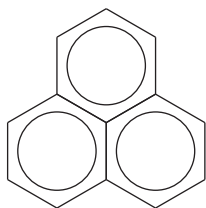


butane

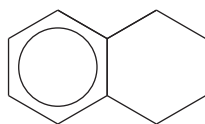


methylpropane

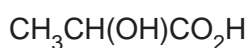
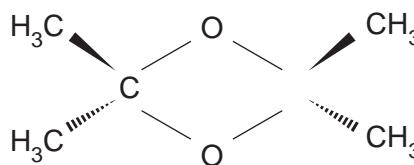
By considering the 3-dimensional geometry of the following five molecules, and allowing rotations around C–C bonds, decide whether or not the **carbon atoms** in each molecule **can be arranged** in a coplanar fashion. Then place a tick in the appropriate column in the table below.



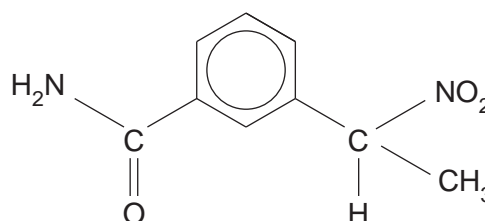
A



B

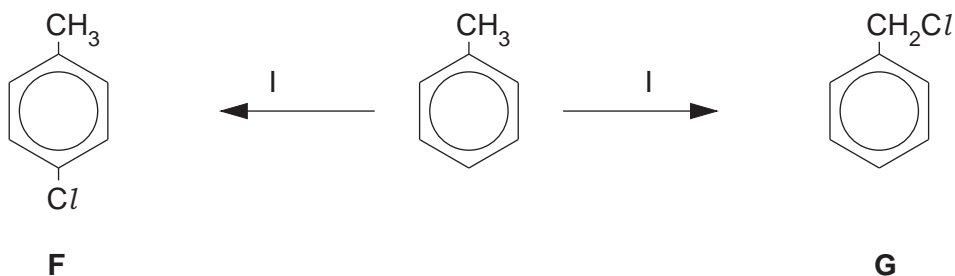


D



compound	all carbon atoms can be coplanar	not all carbon atoms can be coplanar
A		
B		
C		
D		
E		

- (b) Methylbenzene can react with chlorine under different conditions to give the monochloro derivatives **F** and **G**.



Suggest reagents and conditions for each reaction.

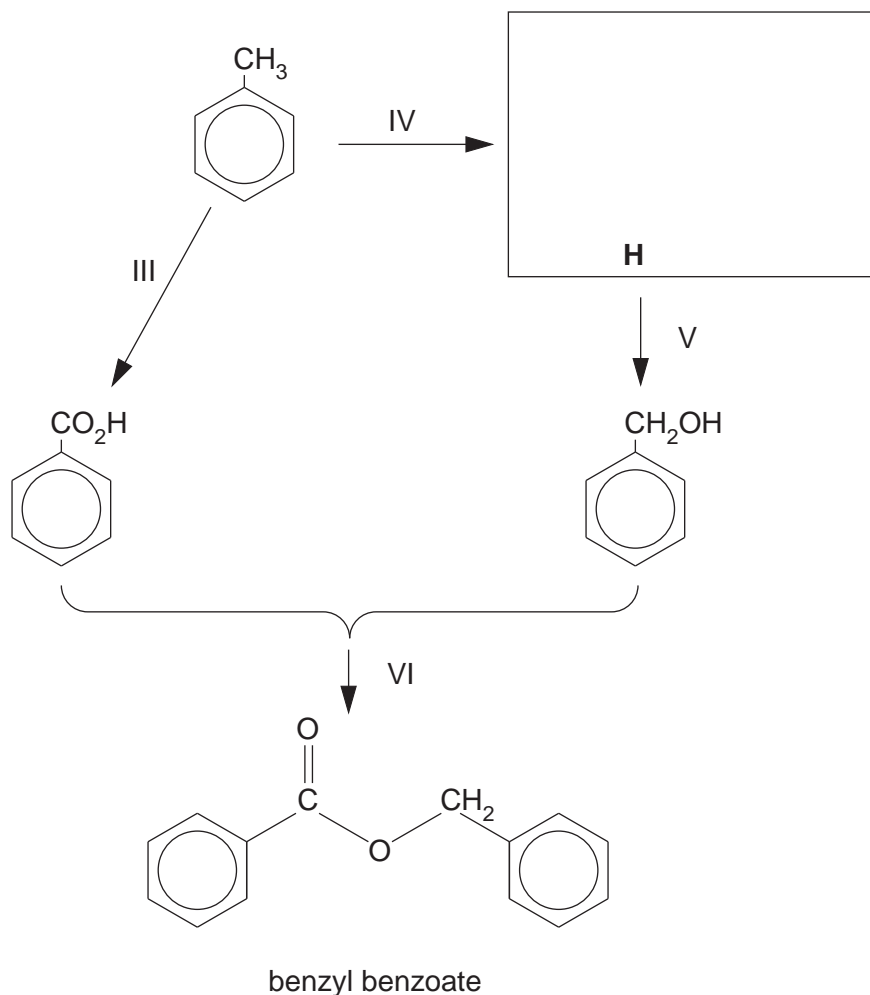
reaction I

.....

reaction II

.....[2]

- (c) Benzyl benzoate is a constituent of many perfumery products, and has also been used in the treatment of the skin condition known as scabies. It can be made from methylbenzene by the following route, which uses one of the chlorination reactions from (b).



- (i) Draw the structural formula of the intermediate **H** in the box above.

(ii) Suggest reagents and conditions for each reaction.

reaction III

.....

reaction V

.....

reaction VI

.....

(iii) State the type of reaction occurring during

reaction III,


.....

reaction V.

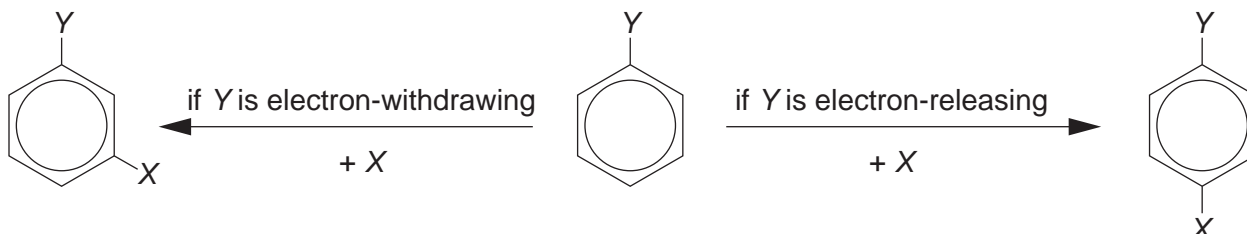
.....

[6]

[Total: 11]

- 6 The substituted benzene compound  can be further substituted.

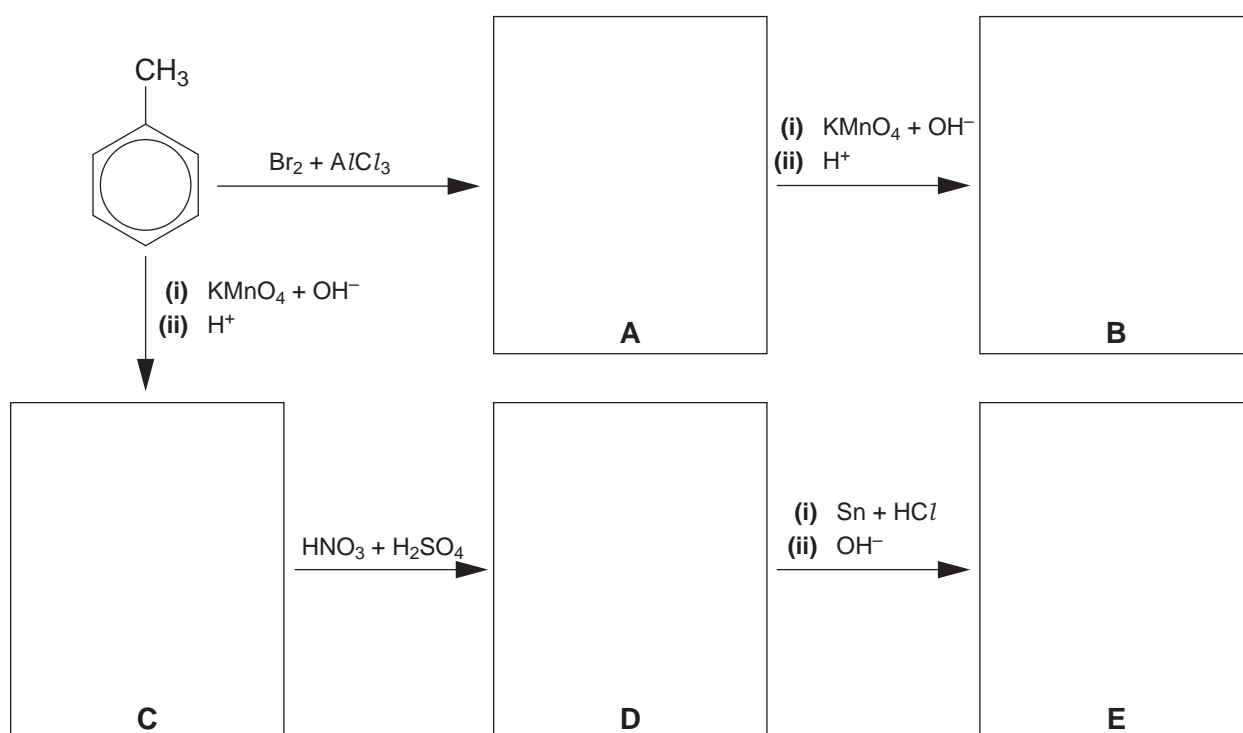
If Y is an electron-withdrawing group, the next substitution will be in position 3.
If Y is an electron-releasing group, the next substitution will be mostly in position 4.



The following table lists some electron-withdrawing and electron-releasing substituents.

electron-withdrawing groups	electron-releasing groups
$-\text{NO}_2$	$-\text{CH}_3$
$-\text{COCH}_3$	$-\text{CH}_2\text{Br}$
$-\text{CO}_2\text{H}$	$-\text{NH}_2$

Use the above information to draw relevant structural formulae in the boxes in the schemes below.

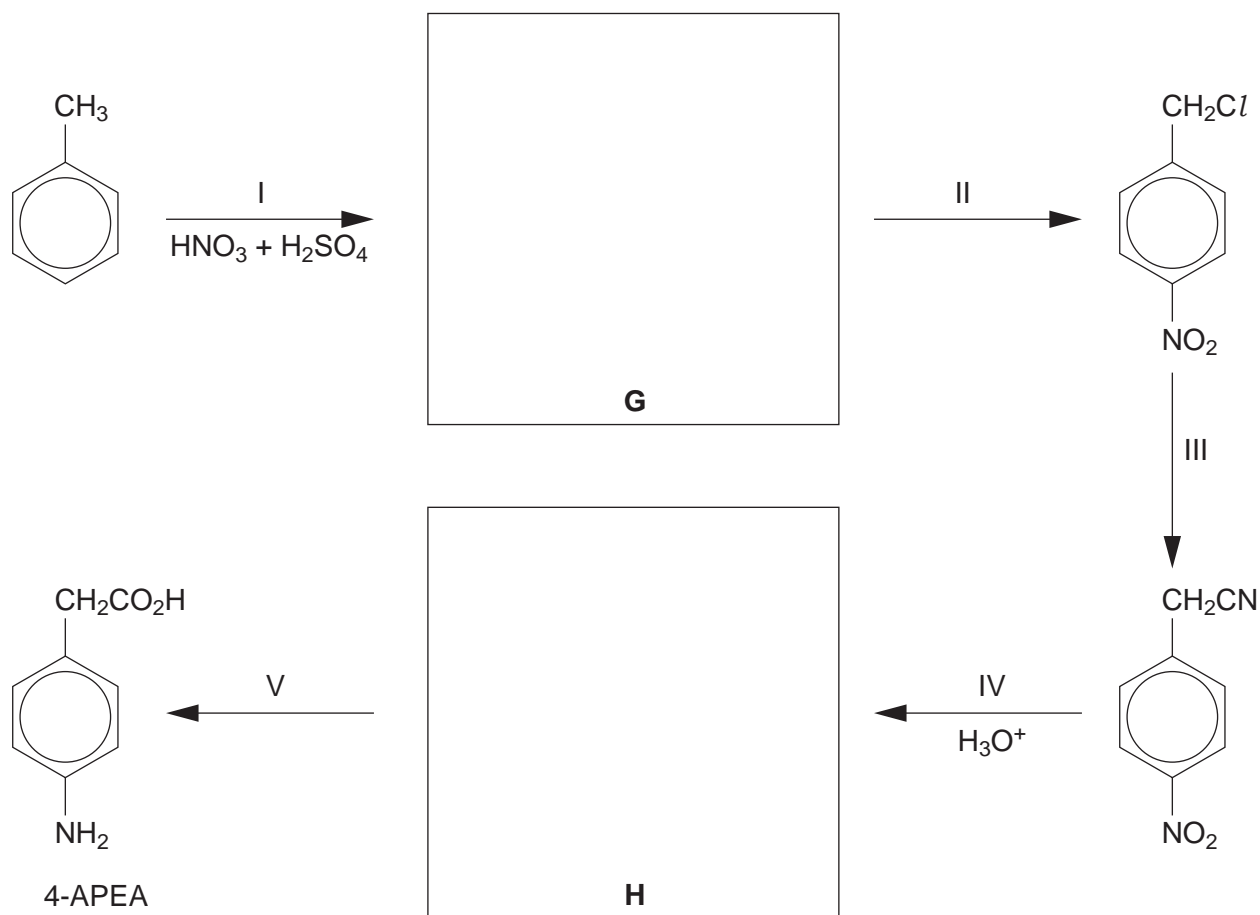


[5]

[Total: 5]

- 7 (4-aminophenyl)ethanoic acid (4-APEA) and its derivatives are being investigated as possible drugs to treat chronic inflammation of the intestines.

The synthesis of 4-APEA from methylbenzene is shown in the following scheme.



(a) Draw the structures of the compounds **G** and **H** in the boxes above. [2]

(b) Suggest reagents and conditions for the following steps.

- step II

.....

- step III

.....

- step V

.....

[3]

[Total: 5]