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CHEMISTRY
ORGANIC CHEMISTRY

Level & Board	CIE (A-LEVEL)
TOPIC:	HYDROCARBONS
PAPER TYPE:	QUESTION PAPER - 1
TOTAL QUESTIONS	10
TOTAL MARKS	87

Hydrocarbons - 1

1)

(a) Some of the larger hydrocarbons in crude oil are subjected to the process of cracking.

(i) What do you understand by the term *cracking*?

(ii) What conditions are used for this reaction?

(iii) Construct a balanced equation to show one possible way in which a molecule of decane, $C_{10}H_{22}$, can be cracked.

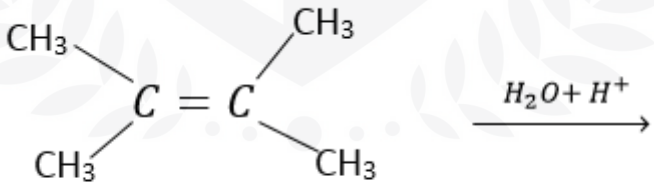
(iv) Briefly explain why cracking is a commercially important process. **[5]**

(b) Name and describe the mechanism of the reaction between ethene and bromine.

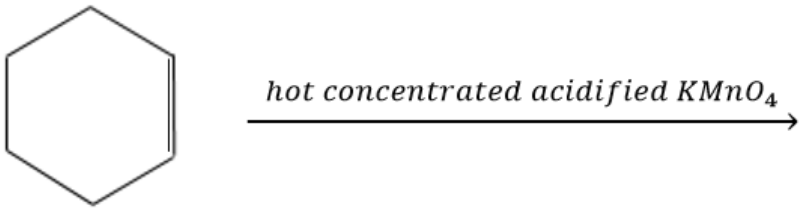
[3]

(c) Predict the product of each of the following reactions.

(i)



(ii)



[2]

2)

(a) (i) State the conditions used for the reaction between ethane and bromine.

$$C_2H_6 + Br_2 \longrightarrow C_2H_2Br + HBr$$

(ii) Why is the described as a *free-radical* substitution reaction?

(iii) Explain why this reaction is an example of homogeneous catalysts. **[4]**

(b) An alkane B is a component of petrol. When treated with bromine under free radical conditions it produces a mixture of brominated compounds. Including C, $C_6H_{12}Br_2$. Dehydrobromination of C produces D, C_6H_{10}. When D is oxidized by hot concentrated $KMnO_4$, three compounds, CO_2, CH_3CO_2H and CH_3COCO_2H, are formed in equimolar amounts.

(i) Suggest reagents and conditions for the conversion of **C** to **D**.

(ii) Suggest a structure for compound **D**, and hence deduce the structure of compound **B**.

(iii) There are four possible isomers of $C_6H_{12}Br_2$ that could give **D** on dehydrobromination. Draw the structures of two of them.

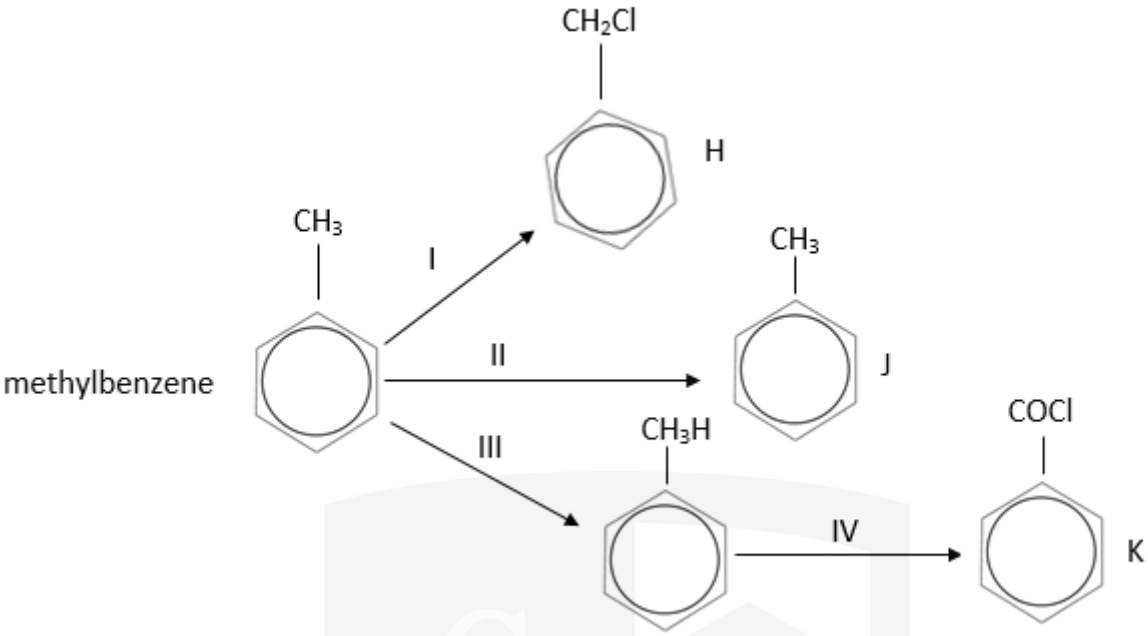
(iv) Suggest, with a reason, the number of stereoisomers of compound **D**. **[6]**

3)

Methylbenzene is a useful starting material for the synthesis of many intermediates used to make pharmaceuticals, dyes and agrochemicals.

(a) Suggest the reagents and conditions needed for each of the reactions I,II, III and IV in the following scheme.

[4]



(b) Describe and explain the relative ease of hydrolysis of the chloro compounds **H**, **J** and **K**.

(c) The electrophile in reaction II is the Cl^+ cation.

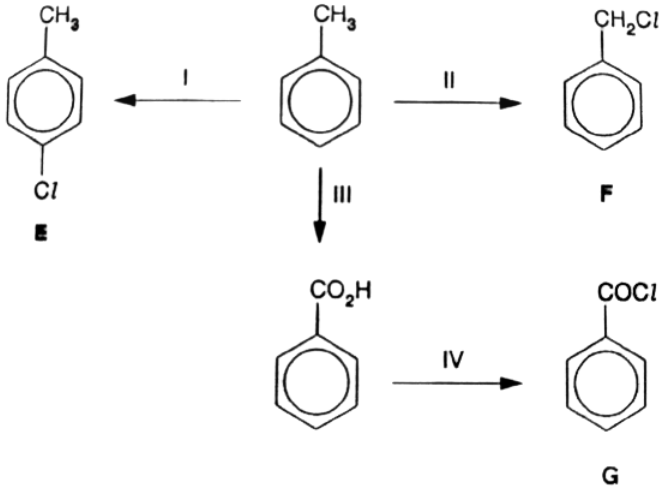
(i) Explain the meaning of the term *electrophile*.

(ii) Suggest how Cl+ is formed from the reagents for reaction II that you mentioned in part (a).

(iii) Suggest the mechanism of the reaction of the electrophile with methylbenzene. **[3]**

4)

The following scheme shows some reactions of methylbenzene.

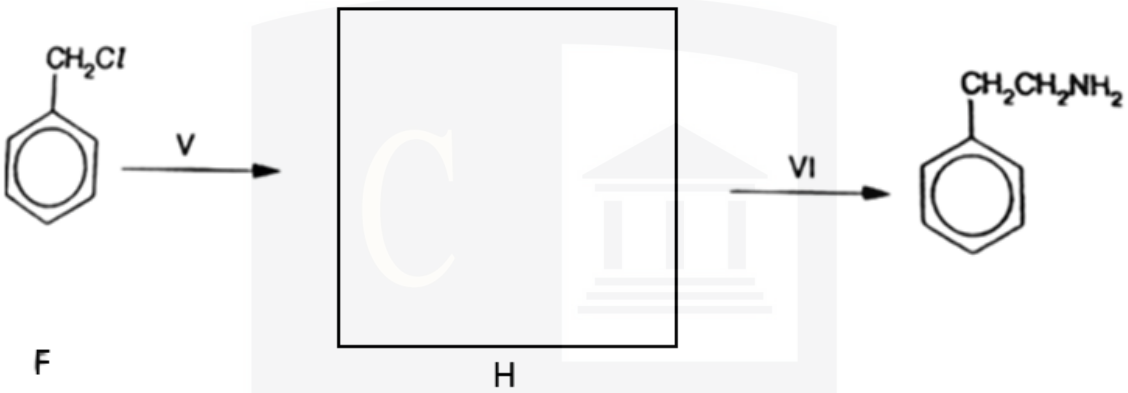


(a) Suggest reagents and conditions for reactions I to IV. **[4]**

(b) What type of reaction is each of the following?

reaction I, reaction III. **[2]**

(d) Compound F can be converted into 2 – phenylethylamine in a two – stage process. Suggest a structure for the intermediate, H, in the box below, and suggest reagents and conditions for the steps V and VI.



Reagents and conditions for step V ……

Reagents and conditions for step VI ……

[4]

(d) The compound E, F and G react at different rates with nucleophilic reagents.

Draw structures for the products of each compound with the following reagents.

If no reaction occurs, write ''***no reaction***'' in the box.

I am Sorry !!!!

compound	reagent	
	cold water	hot NaOH(aq)
E		
F		
G		

[6]

5)

The molecular formula of a compound states the number of atoms of each element that are present in one molecule. It contains no information about the structure of the molecule. Hydrocarbons with the molecular formula C_5H_{10} may be branched chain, straight chain or cyclic.

(a) Draw a displayed formula of C_5H_{10} as a branched chain hydrocarbon **[1]**

Pent – 2 – ene is one straight chain hydrocarbon with formula C_5H_{10}.

(b) Pent – 2 – ene exhibits *cis* – *trans* isomerism. Raw and label the structural formulae of the two *cis* – *trans* isomers of pent – 2 – ene. **[2]**

(c) In the spaces below draw the structural formulae of two alcohols which would each produce pent – 2 – ene on dehydration.

[2]

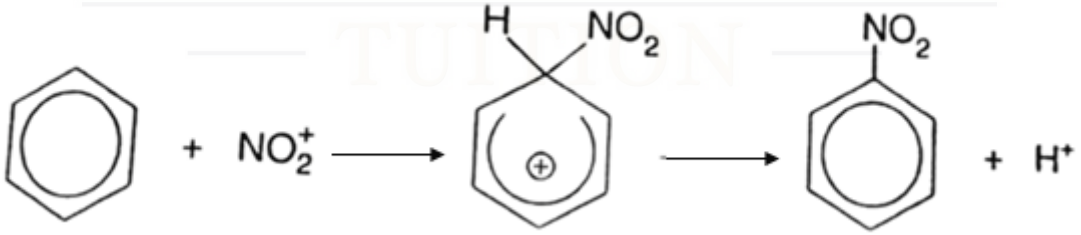
(d) one of these alcohols exhibits optical isomerism. Draw the structural formulae of the two isomers of this alcohol. Your structures should clearly indicate the three – dimensional nature of the structure. **[2]**

(d) Pent – 2- ene decolorises aqueous bromine. Suggest the structural formula of an isomer of C5H10 which does not decolourise aqueous bromine. **[1]**

(f) Pent – 2 – ene can be polymerized. Draw a section of the polymer chain produced showing two repeat units. **[1]**

6)

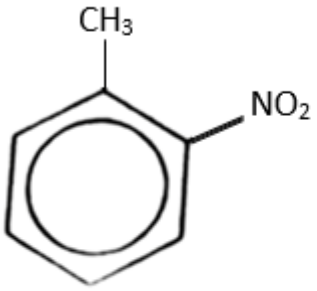
The nitration of benzene occurs in the following steps.



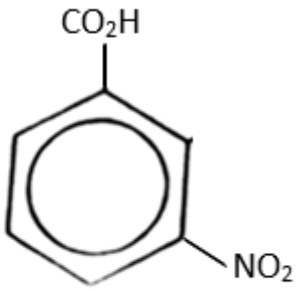
(a) What reagents and conditions are needed for this reaction? **[2]**

(b) Write an equation showing how the electrophile NO_2^+ is formed form the reagents. **[1]**

(c) The nitration of methylbenzene produces mainly 2 – nitromethylbenzene, whereas the nitration of benzoic acid produces mainly 3 – nitrobenzoic acid.

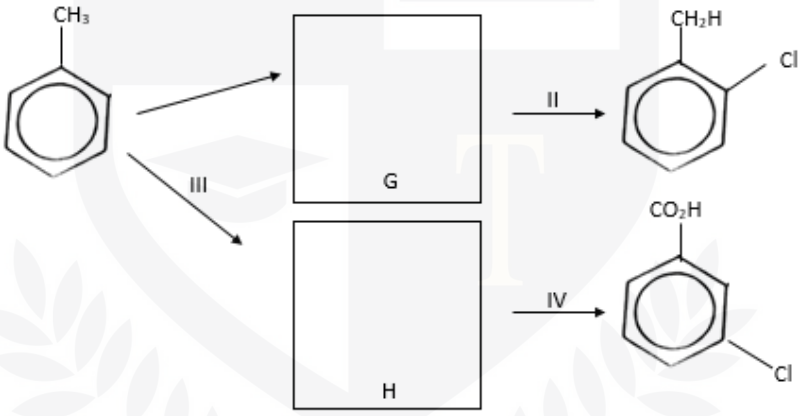


2-nitromethylbenzene



3-nitrobenzoic acid

Use this information to suggest suitable intermediates G and H in the following two 2 – stage syntheses of chlorobenzoic acids, and suggest suitable reagents for reactions I to IV.



reagents:

reaction I ……. reaction II …….

reaction III ……. reaction IV ……. **[4]**

7)

Two types of isomerism found in organic compounds are structural isomerism and cis – trans isomerism.

(a) Draw displayed formulae for

(i) two structural isomers of $C_2H_4Br_2$.

D	E

(ii) the cis – and the trans- isomers of $C_2H_2Br_2$.

cis	trans

[4]

(b) (i) The cis – isomer of $C_2H_2Br_2$ can be converted into one of the structural isomers of $C_2H_4Br_2$. State the reagent(s) and conditions you would use to do this.

(ii) Which of your structural isomers, D or E, would be formed? Explain your answer. **[3]**

8)

Both ethene and benzene react with bromine, but the mechanisms and the types of products of the two reactions are different.

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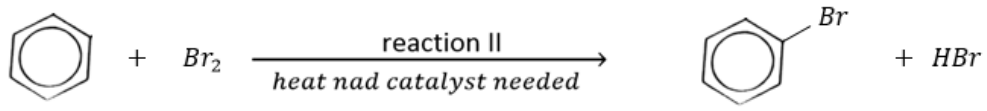
$$H_2C = CH_2 \ + \ Br_2 \xrightarrow[no\ heat, no\ light, no\ catalyst\ needed]{\text{reaction I}} BrCH_2Br$$



(a) State the type of reaction undergone in each of reactions I and II. **[2]**

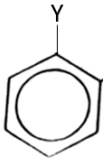
(b) In each of reactions I and II, the intermediate is a bromine – containing cation. In each of the following boxes, draw the intermediate and use curly arrows to show how it is converted into the product.

[4]

(c) Why do ethene and benzene differ in their reaction with bromine? **[1]**

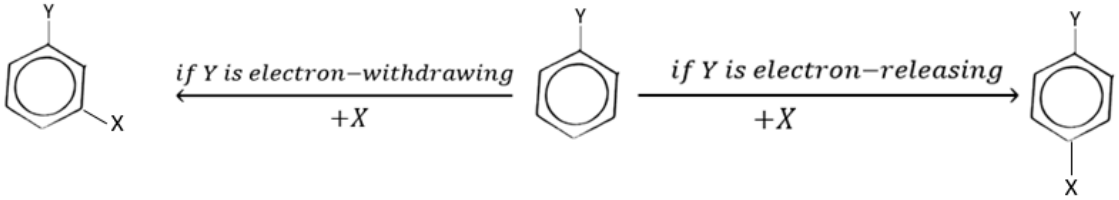
I am Sorry !!!!

9)

The substituted benzene compound 

can be further substituted.

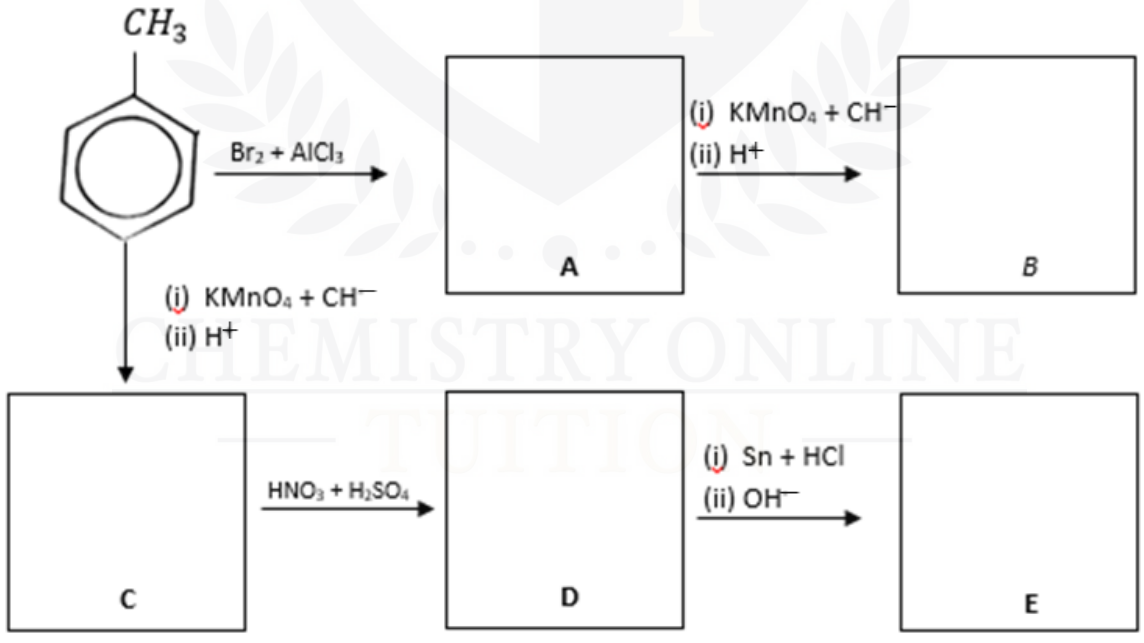
If Y is an electron – withdrawing group, the next substitution will be in position 3. If Y is an electron – releasing group, the next substitution will be mostly in position 4.



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

electron – withdrawing groups	electron – releasing groups
$-NO_2$	$-CH_3$
$-COCH_3$	$-CH_2Br$
$-CO_2H$	$-NH_2$

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



[5]

10)

(a) Natural bromine consists of the two isotopes ^{79}Br and ^{81}Br in roughly equal proportions.

The mass spectrum of bromine consists of 5 peaks.

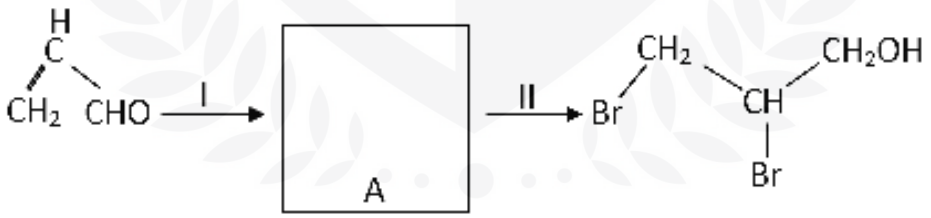
(i) Suggest the mass numbers for the 5 peaks and the identities of the species responsible for them.

(ii) Suggest the ratios of the relative abundances of

- the three lines with the highest mass numbers.
- the two lines with the lowest mass numbers. **[4]**

Esters of 2,3 – dibromopropan – 1 – of with phosphoric acid are useful flame retardants used in plastics and fibers.

2,3 – dibromopropan – 1 – ol can be made fro propenal by the following two stage process.



2,3-dibromopropan-1-ol

(b) (i) Draw the structure of the intermediate A in the box opposite.

(ii) Suggest reagents and conditions for

- reaction I,
- reaction II.

(c) The mass spectrum of 2,3 – dibromopropan – 1 – ol includes the following peaks.

mass number	relative abundance
31	100
106	44
108	45
185	0.3
167	0.6
189	0.3

(i) At what mass number would you expect the molecular ion to occur?

(ii) Identify the molecular formula (including isotopic composition where relavant) of these 6 peaks.

mass number	molecular formula
31	
106	
108	
185	
187	
169	

[5]

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