CHEMISTRY

Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions provided on the Question Paper.
The use of an approved scientific calculator is expected, where appropriate.

The number of marks is given in brackets [ ] at the end of each question, or part question.

This document consists a total of **9** printed pages.

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1 **(a)** Explain why chlorobenzene does **not** undergo nucleophilic substitution with a nucleophilic reagent like sodium hydroxide, **nor** addition reactions with an electrophilic reagent like bromine. [4]

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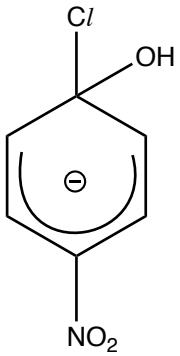
(b) To replace the chloro- group in chlorobenzene, chlorobenzene first undergoes a nitration reaction.

(i) Describe the mechanism of this nitration reaction where 4-nitrochlorobenzene is formed. State the reagents and conditions of this reaction. [4]

(ii) Compare the rate of the nitration reaction if methylbenzene was used instead. Explain your answer. [2]

(iii) When 4-nitrochlorobenzene is reacted with aqueous sodium hydroxide at high temperatures, 4-nitrophenol is formed.

The intermediate below is formed in this reaction.



Distinguish between the 6 carbon atoms in terms of their hybridisation and the number of pi electron(s) they carry. [3]

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(c) It is known that benzene has 6 *delocalised* electrons in its 6-membered ring.

(i) Explain the meaning of the word *delocalisation* or *delocalised* in the context of the structure and bonding in

- benzene; and
- graphite. [2]

(ii) With reference to your answer in **(i)**, explain why benzene is a **non**-conductor of electricity, but graphite is a conductor of electricity. [2]

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[Total: 17]

2 **(a)** Describe the mechanisms where butan-2-ol is formed from 2-chlorobutane via the S_N1 and S_N2 mechanism. [6]

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(b) Draw the structures of the unknowns, **1** to **8**, of the following reactions. [8]

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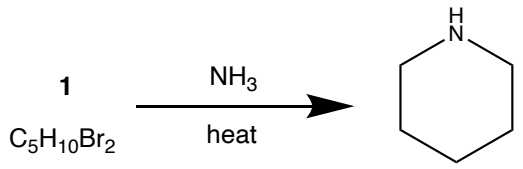
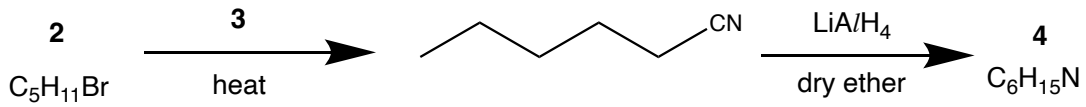
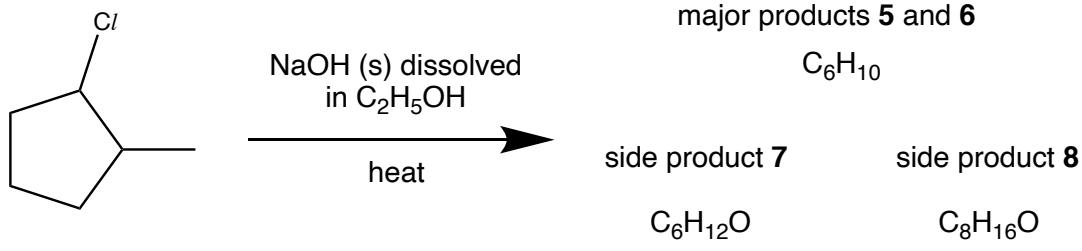


(ii)



(iii)


Cl
NaOH (s) dissolved in C_2H_5OH
heat
major products **5** and **6**
C_6H_{10}
side product **7**
$C_6H_{12}O$
side product **8**
$C_8H_{16}O$

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(c) Explain how, with a simple chemical test, you would distinguish between 1-chlorobutane and 1-bromobutane. [3]

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(d) Neopentyl chloride, $(CH_3)_3CCH_2Cl$, is a primary alkyl halide that does **not** undergo nucleophilic substitution.

(i) Explain why neopentyl chloride cannot undergo the S_N1 mechanism. [1]

(ii) Suggest why neopentyl chloride cannot undergo the S_N2 mechanism, with reference to steric factors. [1]

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[Total: 19]