

Chapter 1

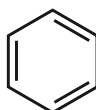
Arenes and phenols

Print out and complete this worksheet to generate a summary for Chapter 1.

Structure of benzene

1 a Benzene contains 92.3% C and 7.7% H and has an M_r value of 78.0. Calculate the empirical and molecular formulae of benzene.

b The Kekulé structure of benzene consists of a hexagonal ring with alternating double and single bonds:



(i) State three pieces of evidence that suggest that this structure is not correct.

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(ii) Explain, with the aid of a suitable diagram, how clouds of delocalised electrons are formed above and below the plane of benzene. State the bond angles in benzene.

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C Draw the displayed formula of each of the following compounds. Give the size of the bond angles:

(i) methylbenzene, $\text{C}_6\text{H}_5\text{CH}_3$

(ii) 2,4,6-trichlorophenol, $\text{C}_6\text{H}_2\text{Cl}_3\text{OH}$

(iii) phenylethene, $\text{C}_6\text{H}_5\text{CH}=\text{CH}_2$

Electrophilic substitution of arenes

2a Explain what is meant by:

(i) an electrophile

(ii) substitution

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b Benzene can be nitrated to form nitrobenzene.

(i) State the reagents required.

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(ii) State the conditions used.

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(iii) Write a balanced equation for the reaction.

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c Outline the mechanism for the nitration of benzene by completing the steps below:

Step 1: formation of the electrophile

Step 2: electrophilic attack at the ring (Don't forget the 'smiley face' intermediate carbonium ion)

Step 3: regeneration of the H_2SO_4 catalyst

d Outline the mechanism for the chlorination of benzene by completing the steps below:

Step 1: formation of the electrophile

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State the type of bond fission in the Cl–Cl bond.

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Step 2: electrophilic attack at the ring. (Don't forget the 'smiley face' intermediate carbonium ion.)

Step 3: regeneration of the catalyst.

e Complete parts (i)–(v) to compare the relative resistance to bromination of benzene and cyclohexene.

(i) Balanced equation

benzene:

cyclohexene:

(ii) Conditions

benzene:

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cyclohexene:

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(iii) Type of reaction:

benzene:

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cyclohexene:

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(iv) Type of bond fission in the Br₂ molecule:

benzene:

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cyclohexene:

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(v) Electron densities:

benzene:

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cyclohexene:

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(vi) Explain why it is more difficult to react bromine with an arene than with an alkene.

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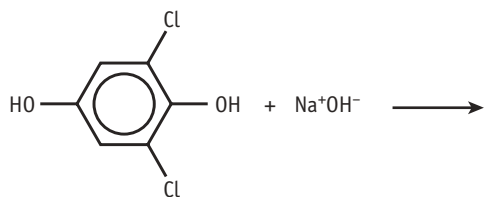
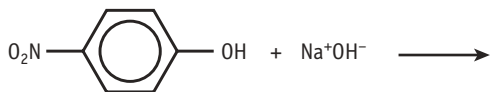
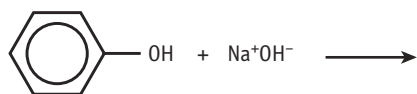
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Phenols

3 a Phenols react with alkalis, for example aqueous sodium hydroxide.

(i) Complete the following equations:

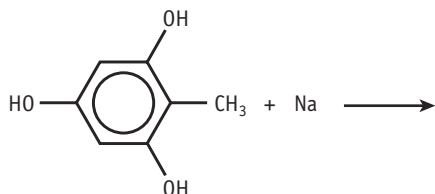
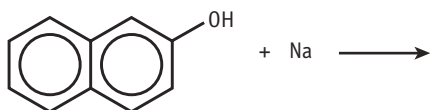
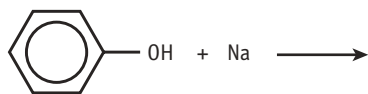


(ii) What do the reactions of phenols with NaOH(aq) in part (i) tell you about the acidity of phenols?

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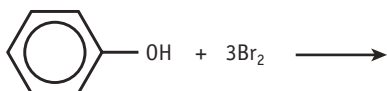
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- b** Phenols also react with reactive metals, for example sodium. Complete the following equations:



- c** Phenol reacts readily with bromine to form 2,4,6-tribromophenol.

- (i) Complete the equation below.



- (ii) Explain the relative ease of bromination of phenol compared with benzene.

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- d** State two uses of phenols. Use your textbook or the internet to find specific examples.

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