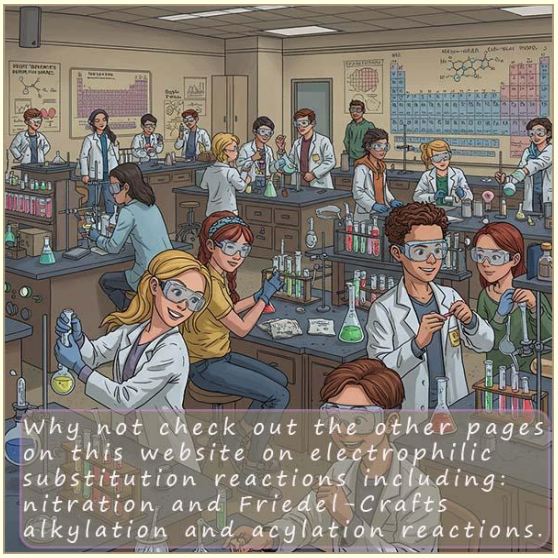

Answer all the questions below as fully as you can then check your answers

1. Which of the following best describes the reaction of benzene with bromine in the presence of $FeBr_3$?

a) Electrophilic addition  b) Nucleophilic substitution

c) Electrophilic substitution  d) Free radical substitution




2. Bromine water is used to test for unsaturation in alkenes. Explain why bromine water decolourises when added to cyclohexene but not when added to cyclohexane.

3. What is the role of $FeBr_3$ in the bromination of benzene?

b) Explain how $FeBr_3$ enables the reaction to occur.

4. Why do aromatic compounds like benzene undergo electrophilic substitution reactions, whereas alkenes undergo electrophilic addition reactions?

5. Draw the mechanism for the bromination of benzene, including the structure of the intermediate carbocation and showing the regeneration of the catalyst. Explain the movement of electrons using curly arrows.

6. Some simplified representations of the bromination of benzene show $Br^+$ as the electrophile. Discuss why this is a simplification and what the actual electrophile is.

7. You are given two unlabeled bottles, one containing cyclohexane and the other containing benzene. Describe a simple chemical test you could perform to distinguish between the two liquids.

## Answers

1. Which of the following best describes the reaction of benzene with bromine in the presence of $FeBr_3$?

a) Electrophilic addition b) Nucleophilic substitution

c) Electrophilic substitution d) Free radical substitution

Answer: c) Electrophilic substitution

2. Bromine water is used to test for unsaturation in alkenes. Explain why bromine water decolourises when added to cyclohexene but not when added to cyclohexane.

Answer: Cyclohexene contains a C=C double bond, making it unsaturated. Bromine adds across this double bond in an electrophilic addition reaction, consuming the bromine and causing the colour to disappear. Cyclohexane is saturated (no C=C bonds) and therefore does not react with bromine water.

3. What is the role of $FeBr_3$ in the bromination of benzene?

b) Explain how $FeBr_3$ enables the reaction to occur.

Answer:

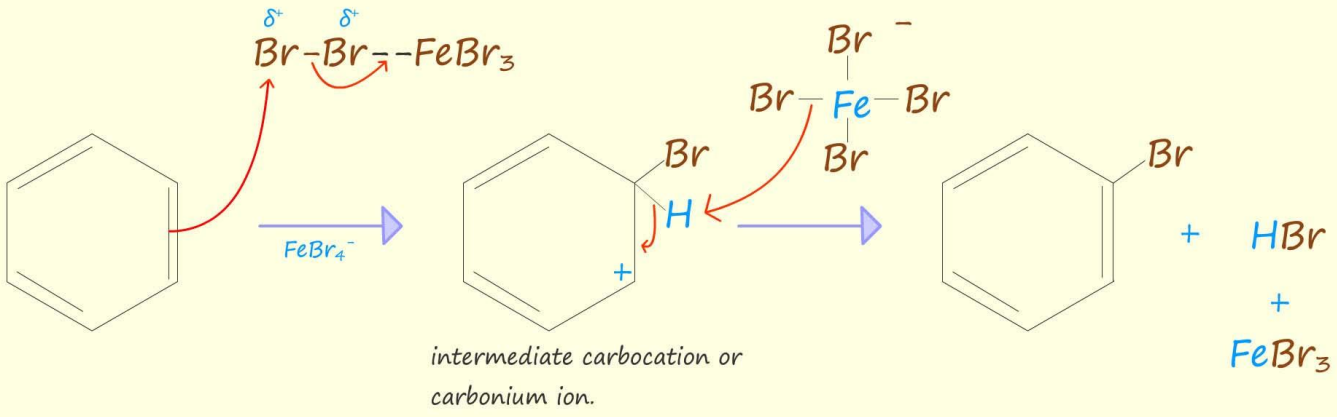
a) $FeBr_3$ acts as a Lewis acid catalyst (or halogen carrier).

b) $FeBr_3$ polarises the $Br_2$ molecule, forming the $Br_2$-$FeBr_3$ complex, which is a much stronger electrophile than $Br_2$ itself. This stronger electrophile is necessary to overcome the stability of the benzene ring and allow the electrophilic substitution reaction to proceed.

4. Why do aromatic compounds like benzene undergo electrophilic substitution reactions, whereas alkenes undergo electrophilic addition reactions?

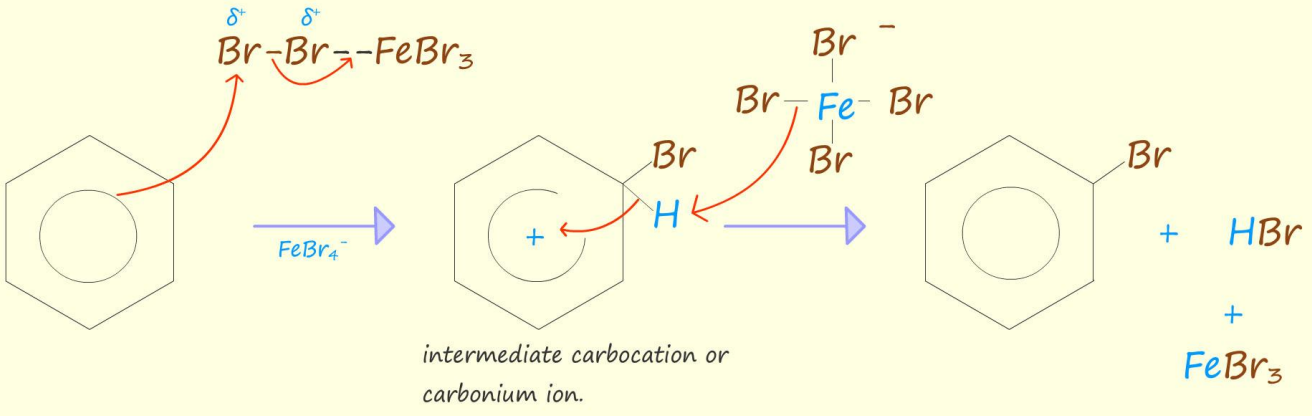
Answer: Alkenes have localised pi electrons in the C=C double bond, making them susceptible to addition reactions. Benzene's pi electrons are delocalised across the ring, resulting in significant stability (aromaticity). Addition to benzene would destroy this delocalisation and the associated stability, making substitution, which preserves the aromatic ring, the favoured pathway.

5. Draw the mechanism for the bromination of benzene, including the structure of the intermediate carbocation and showing the regeneration of the catalyst. Explain the movement of electrons using curly arrows.



intermediate carbocation or carbonium ion.

Or



intermediate carbocation or carbonium ion.

6. Some simplified representations of the bromination of benzene show $Br^+$ as the electrophile. Discuss why this is a simplification and what the actual electrophile is.

Answer: While $Br^+$ is often used for simplicity, it's not the actual electrophile. The real electrophile is the polarised $Br_2$ molecule or, more accurately, the $Br_2$-$FeBr_3$ complex. This complex is a much stronger electrophile due to the polarisation induced by the Lewis acid catalyst. Representing the electrophile as $Br^+$ oversimplifies the process and doesn't accurately reflect the interaction between $Br_2$ and $FeBr_3$.

7. You are given two unlabeled bottles, one containing cyclohexane and the other containing benzene. Describe a simple chemical test you could perform to distinguish between the two liquids.

Answer: Add bromine water to each bottle. The bromine water will rapidly decolorize in the presence of cyclohexene (due to electrophilic addition). With benzene, no immediate reaction will be observed without a catalyst. If a catalyst (FeBr3) is added to the benzene, then the bromine colour will fade.