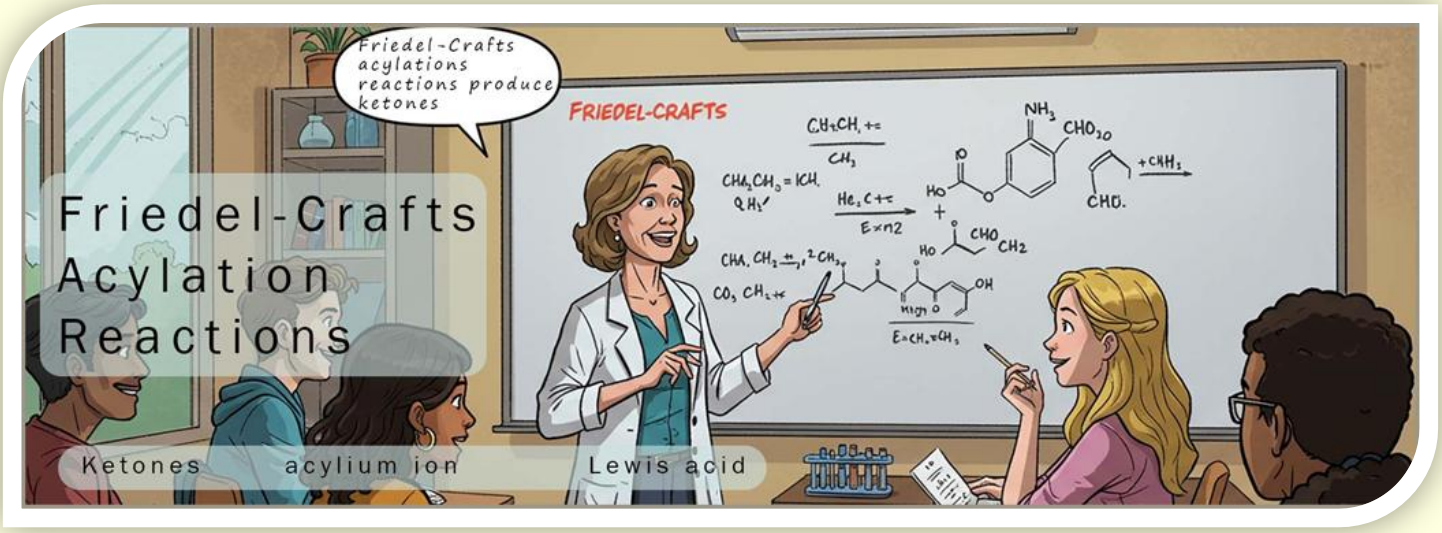


Answer all the questions below as fully as you can then check your answers

1. Which of the following is the electrophile in a Friedel-Crafts acylation reaction?

a) R-Cl b) $AlCl_3$ c) RCO^+ d) H^+

2. What is the primary advantage of Friedel-Crafts acylation over Friedel-Crafts alkylation?

a) It is faster.

b) It uses less catalyst.

c) It avoids polyalkylation.

d) It produces a higher yield.

3. Which reagent is NOT typically used to generate the acylium ion?

a) Acid chloride

b) Acid anhydride

c) Alkene

d) A carboxylic acid derivative

4. Explain why the acylium ion is resonance stabilised. Draw the resonance structures of the acylium ion formed when ethanoyl chloride reacts with the Lewis acid aluminium chloride.

5. Describe the role of the Lewis acid catalyst (e.g., $AlCl_3$) in the Friedel-Crafts acylation reaction.

6. Write the overall equation for the reaction of benzene with propanoyl chloride (CH_3CH_2COCl) in the presence of $AlCl_3$. Name the organic product formed.

7. Explain why Friedel-Crafts acylation reactions do not suffer from the same poly-substitution problems as Friedel-Crafts alkylation reactions.

8a. Outline the mechanism for the reaction of benzene with ethanoyl chloride (CH_3COCl) in the presence of anhydrous aluminium chloride. Include curly arrows to show the movement of electrons.

(b) Explain why this reaction is an example of electrophilic substitution.

(c) What are the reaction conditions for this reaction?

9. Compound X (C_8H_8O) is formed when benzene reacts with ethanoyl chloride (CH_3COCl) in the presence of anhydrous aluminium chloride.

Draw the structural formula of Compound X.

b. Describe a simple chemical test to confirm the presence of the carbonyl group in Compound X.

c. Compound X is reduced using hydrogen and a nickel catalyst. Write the equation for the reaction and name the product formed.

Answers

1. Which of the following is the electrophile in a Friedel-Crafts acylation reaction?

a) R-Cl b) $AlCl_3$ c) RCO^+ d) H^+

Answer: c) RCO^+

2. What is the primary advantage of Friedel-Crafts acylation over Friedel-Crafts alkylation?

a) It is faster. b) It uses less catalyst.

c) It avoids polyalkylation. d) It produces a higher yield.

Answer: c) It avoids polyalkylation.

3. Which reagent is NOT typically used to generate the acylium ion?

a) Acid chloride b) Acid anhydride

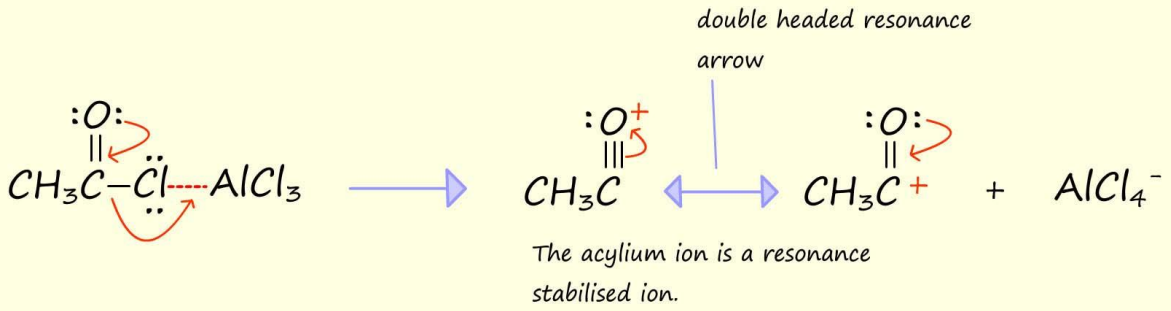
c) Alkene d) A carboxylic acid derivative

Answer: c) Alkene

4. Explain why the acylium ion is resonance stabilised. Draw the resonance structures of the acylium ion formed when ethanoyl chloride reacts with the Lewis acid aluminium chloride.

Answer:

The positive charge on the acylium ion is delocalized over the carbon and oxygen atoms due to the presence of the π bond. This delocalization stabilises the ion.



5. Describe the role of the Lewis acid catalyst (e.g., $AlCl_3$) in the Friedel-Crafts acylation reaction.

Answer: $AlCl_3$ acts as a Lewis acid catalyst. It accepts a lone pair of electrons from the chlorine atom of the acyl chloride, forming a complex and generating the highly reactive acylium ion (RCO^+).

6. Write the overall equation for the reaction of benzene with propanoyl chloride (CH_3CH_2COCl) in the presence of $AlCl_3$. Name the organic product formed.

Answer:

$C_6H_6 + CH_3CH_2COCl + AlCl_3 \rightarrow C_6H_5COCH_2CH_3 + HCl + AlCl_3$

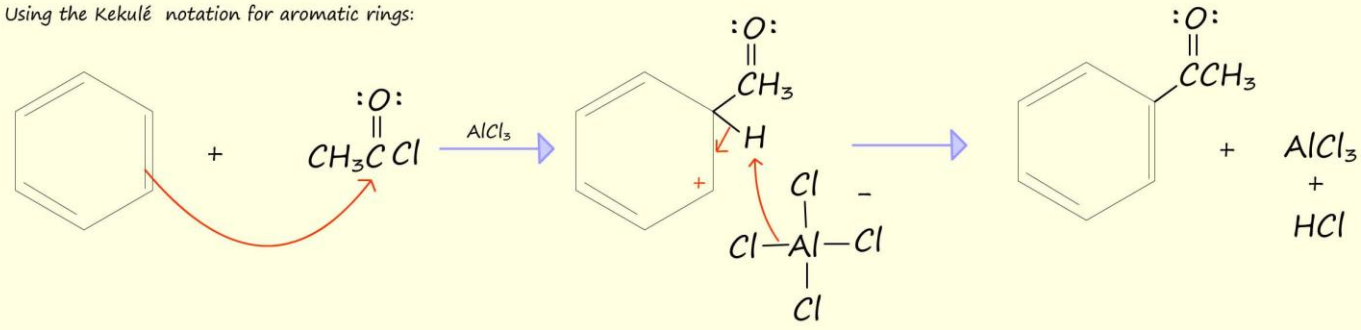
(propanoylbenzene or 1-phenylpropan-1-one)

7. Explain why Friedel-Crafts acylation reactions do not suffer from the same poly-substitution problems as Friedel-Crafts alkylation reactions.

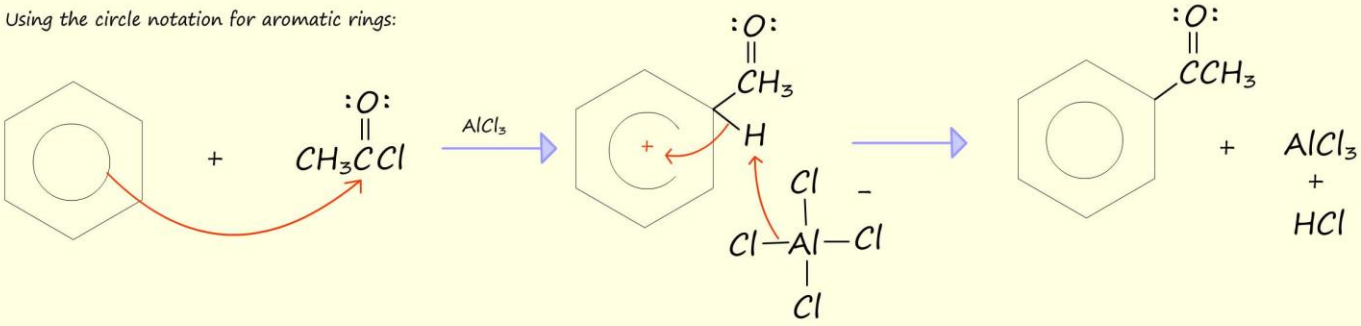
Answer: The acyl group (-COR) is an electron-withdrawing group. Once it is attached to the benzene ring, it deactivates the ring towards further electrophilic attack, preventing polyacylation.

8a. Outline the mechanism for the reaction of benzene with ethanoyl chloride (CH_3COCl) in the presence of anhydrous aluminium chloride. Include curly arrows to show the movement of electrons.

Using the Kekulé notation for aromatic rings:



Using the circle notation for aromatic rings:



(b) Explain why this reaction is an example of electrophilic substitution.

Answer: The reaction involves the substitution of a hydrogen atom on the benzene ring by the electrophilic acylium ion.

(c) What are the reaction conditions for this reaction?

Answer: Anhydrous conditions (to prevent the Lewis acid catalyst from reacting with water and reflux to provide sufficient energy for the reaction to occur. Temperature around 80°C

9. Compound X (C_8H_8O) is formed when benzene reacts with ethanoyl chloride (CH_3COCl) in the presence of anhydrous aluminium chloride.

Draw the structural formula of Compound X.

Answer: $C_6H_5COCH_3$ (phenylethanone/acetophenone)

b. Describe a simple chemical test to confirm the presence of the carbonyl group in Compound X.

Answer: Add 2,4-dinitrophenylhydrazine (Brady's reagent). A yellow/orange precipitate indicates the presence of a carbonyl group.

c. Compound X is reduced using hydrogen and a nickel catalyst. Write the equation for the reaction and name the product formed.

Answer:

$$C_6H_5COCH_3 + H_2 \rightarrow C_6H_5CH(OH)CH_3 \text{ (1-phenylethanol)}$$